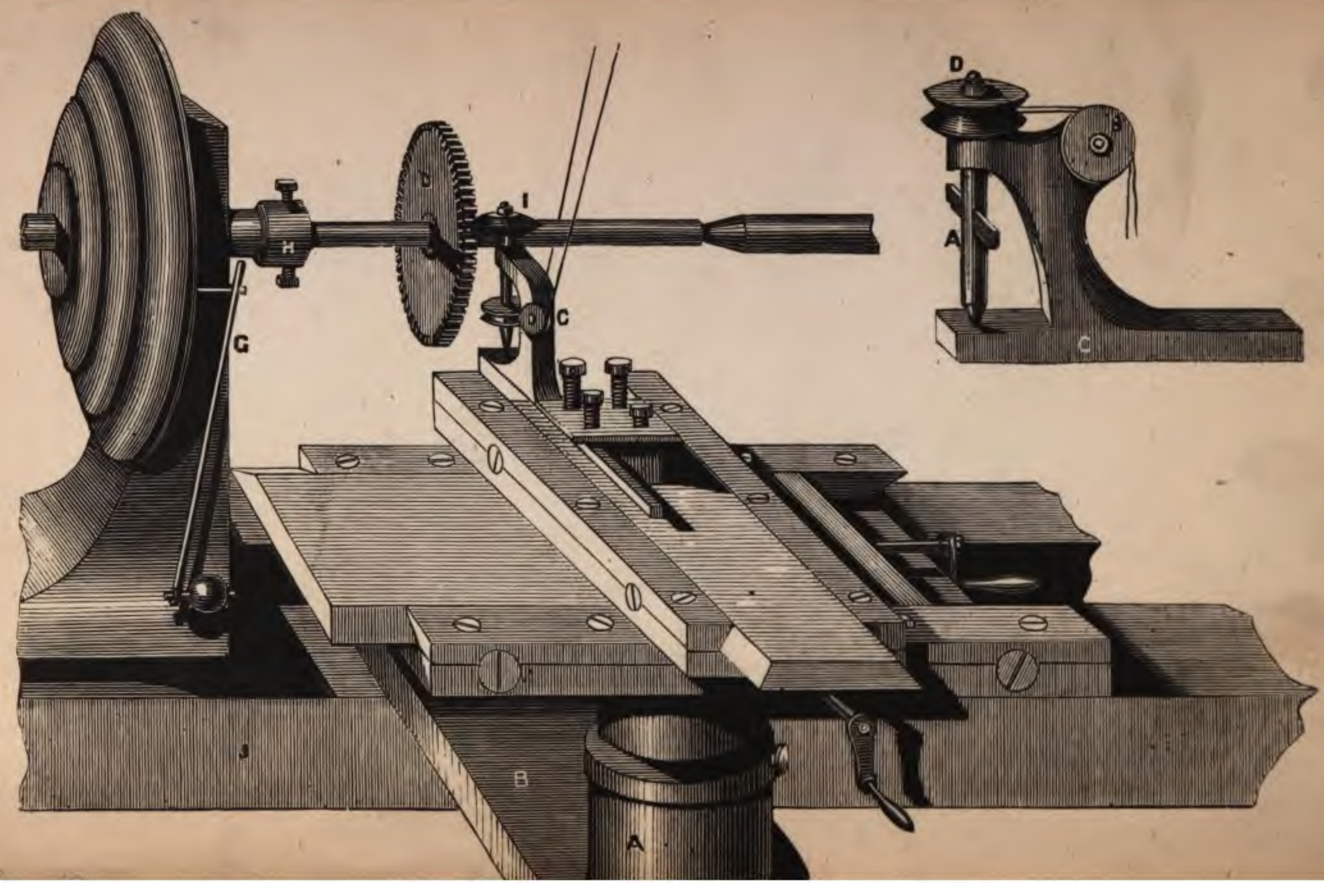

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THE

AMATEUR MECHANIC'S WORKSHOP:

A TREATISE

CONTAINING PLAIN AND CONCISE DIRECTIONS

FOR THE

MANIPULATION OF WOOD AND METALS,

INCLUDING

CASTING, FORGING, BRAZING, SOLDERING,

AND CARPENTRY.

BY

THE AUTHOR OF THE "LATHE AND ITS USES."

James Lukin

Third Edition.

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PREFACE.

The following pages are intended to supply a want long felt by amateur mechanics of a handy book on the various operations of the workshop. The only work of the kind which includes manipulation in wood and metal is that by Holtzapffel, in three expensive volumes, a work of immeasurable value, to which not only the writer of the present treatise, but all who have of late years attempted similar productions, are infinitely indebted. The scope, however, of the above is almost of necessity too extensive, as the whole is too costly for the purposes of the general amateur. It was, indeed, designed as an introduction to a comprehensive work on the lathe, and though in a manner complete in itself, it is yet evidently arranged with that ultimate object in view. Hence there appears to be still room for some such concise treatise as is now offered to the amateur; and it is hoped that the following "Hints" (for it pretends to little more) may suffice to render more easy those manifold and varied operations carried on with more or less success in the workshop of the amateur mechanic.

INDEX.

THE AMATEUR MECHANIC'S WORKSHOP.

"OLD FILE" need hardly inform the readers of these pages that he has long occupied a place at the bench, and has, in spite of certain asperities of his nature, been received with all honour into every workshop in the three kingdoms, and far enough beyond their confines. Being of a practical turn of mind and naturally sharp, and of temper irreproachable, he has been allowed an insight into various mechanical operations, and has noted down his observations. Overhauling these notes, he finds that they would have supplied answers to at least half the queries addressed to the editors of our mechanical and engineering periodicals, and as the present state of his teeth remind him that he must soon become a useless old fellow, he has determined while there is life in him, to publish his "Annotations" and "Reflections" in the form of "Hints to Amateurs on the general Operations of the Workshop." The design is not indeed "pretentious," and as to criticism of style or matter, "Old File" need only repeat that his skin is hard, and almost impermeable, while his temper, in common parlance, leaves nothing to be desired. "Old File" has made his bow.

The amateur mechanic is certainly of the order composite; his

trade absolutely indefinable. Blacksmith and carpenter, turner and misfitter,* he has to acquire a vast amount of practical skill, without the advantages of a regular apprenticeship. The wonder is not that he sometimes fails, but rather that he ever succeeds in turning out even decent work. Nevertheless, that he does so is beyond question, not indeed always, nor perhaps generally, but "Old File" himself has seen such work as would shame many a professional, executed by men whose birth and education, mind, body, and estate, entirely precluded the necessity of applying their right hand to the workman's hammer. And "Old File" set himself to inquire the character of these successful amateurs, that he might learn, if possible, the origin of their success. The result of his inquiries may be written in three words—"patient," "persevering," "intelligent."

The amateur in general lacks one at least of the above qualifications, most commonly the first. He is in such a hurry to drive the *last* nail, or to enter the *last* screw, that he splits his wood with the *first*, crosses the thread of the other, and spoils the whole concern. A good workman never hurries, nor again does he begin a piece of work without having first conned the details, and with pencil and compasses sketched his design in its completeness. I have seen, for example, an amateur working at a model engine, without having even decided whether he should make it vertical, horizontal, beam, or oscillating ; and as to such details as the form of guide to the piston, lap of valve, or radius of eccentric—all that and much more was supposed to come of itself at the required time. Let it be stated (as a secret, mind) that after divers alterations of design the component parts of the above still lie in a drawer in company with many similar failures, and will eventually find a place in "Our Subscribers' Exchange Club."

First of all, therefore, decide upon what you intend to do, consider if possible at the onset all details of the model or other work, and set about the same with the utmost deliberation, not caring

* "Old File's" notes being blurred, it is possible that the first syllable of this word is an interpolation.

whether it may cost you a week's labour or a month's, so long as the end shall prove satisfactory.

Again, there are several ways of setting about your work, and some consideration is requisite to determine where to begin, and the best and straightest course to the desired end. Here, no less than in the actual use of the tools, is needed the third qualification—"intelligence."

Beware of desultory methods of work—such as cutting a screw or two to-day, because you feel in a humour for it, toying with the file to-morrow upon some unimportant part which cannot yet be fitted because its appointed place is not prepared for it, and so forth; if not in a humour for steady application and painstaking labour at the work bench, leave it alone, for you are sure to waste your time, and make bad work. One great secret indeed of the professional mechanic's success, is the absolute necessity he lies under of making the most of his time and of the means and appliances within his reach. Thus, while practically acknowledging the truth of that wise saw, "The more haste the worse speed," he is careful not to waste the precious working hours of life by desultory and ill-advised efforts. He does the right thing in the right way deliberately, yet with sufficient speed to produce the fair remuneration of the intelligent and accomplished artisan.

THE FOUNDRY.

It is not our intention to enter into a detailed description of the art of casting metals, but only to give the reader a sufficient insight into the process to enable him to make his own patterns, and thereby save considerable expense. It is not pleasant, after much time and labour have been expended upon the wooden model, to hear the decision of the founder that it is quite impossible to mould and cast it in metal. Yet nothing is more common, and the cherished pattern has frequently to be cast aside, and replaced

by one of totally different construction. The principle of casting is very simple—a model of the required work is laid in sand or loam, and being afterwards removed, leaves its impress in the same, into which the melted metal is poured, and thus caused to assume the exact form of the pattern. The box or case which holds the sand is called a flask, and consists generally of two, and not unfrequently of many parts. These flasks are sometimes made of wood, but more usually of cast iron, the common form being that

FIG 1

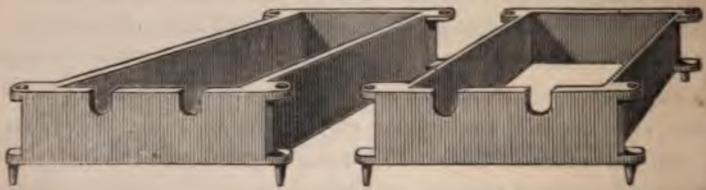
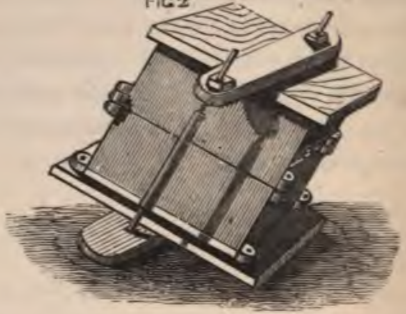


FIG 2



of a square or oblong box without top or bottom, and with projecting lugs and pins, so that when two or more are required in combination, they may be readily fitted together always in the same relative position. The first figure represents a pair of such flasks separated, the second shows the same united and additionally secured by a screw clamp. Suppose it to be required to cast a sphere—an iron cannon ball, for instance. The pattern having been made in wood or other suitable material can of course be easily embedded in a single flask of sand, but as soon as you attempt to

withdraw it, you necessarily break down the matrix. But by taking a double flask as in the figure, and merely embedding half the ball in the lower one, levelling the surface of the sand precisely on the diametrical line, and doing the same with the upper one, you can, by afterwards parting the flasks on the same line, remove the pattern, the impress of which will consequently remain half in the one and half in the other, and when, by means of the lugs and pins, the flasks have been reunited, you will have a perfectly spherical cavity to be filled by means of a channel or runner left for that purpose. The actual details of this operation will be noted presently.

In Fig. 3 is shown a row of patterns of various sections; A is supposed to be the level of the upper surface of the top flask, B

FIG 3

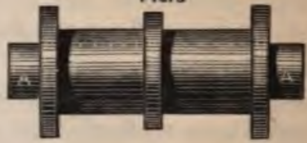
the line of parting, being the upper surface of the lower flask, and C the bottom of the same; 1 and 2 might lie completely in the lower flask; 3 being supposed to be a cone with its apex towards the left, might be placed as shown or embedded with the point downwards; 4 being a cylinder may be placed vertically, or as in the figure; but 5, representing a hollow box or cup, must of necessity lie as shown, for it is evident that if it were inverted or laid on its side it could not be removed without breaking down the sand. The latter is a hollowed work said to deliver its own core, but the majority of such patterns—a hollow cylinder, for instance, *with flanges* like that of a steam engine—would have to be altogether differently arranged, requiring a pattern with prints as they are called, and in addition a core box, the nature of which will be now explained.

CORED WORK.

Let it be required to cast a cylinder of the form shown in Fig. 4—a pattern turned hollow like the finished work must evidently break down the sand, turn it which way you please in the flask. If placed vertically the flanges will prevent it from delivering—if laid horizontally the interior will not be moulded;

FIG. 4.

FIG. 5



hence a different arrangement is needed. The pattern must be turned as a solid cylinder with its outside flanges complete, but in place of a hollow interior, two projecting pieces A (Fig. 5) are left, called prints. These are of a diameter regulated by the intended thickness of metal, as will be understood by referring to Fig. 7.

FIG. 6

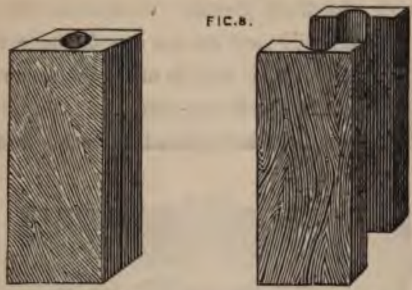
FIG. 7

If such a pattern is laid in the sand of the lower flask as far as its axial line A B (Fig. 6) the prints will leave indentations, in which, reaching across from one to the other, the core will lie, and round it the poured metal will run. This core is shown at A (Fig. 7), where the space for the metal is left white.* It is made of sand,

* In the figure the flanges should be left white, the core being cylinprical and represented by the central parts A A, and the projecting ends.

loam, or a mixture of the two rammed tightly into a core box such as Fig. 8. The latter is sawn through and fitted together with guides or steady pins, after which a screw clamp is fixed round it. When the core is tolerably dry the box is opened and the contents further dried and then baked, the result being in the

FIG. 8.



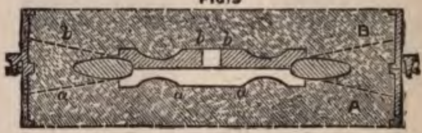
present case a solid cylinder. Of course both core box and prints may be of any desired form according to the requirements of the object to be cast. It frequently happens that the pattern by being made in two or more parts may be so contrived as to dispense with the necessity of cores and core boxes; which latter are sometimes, from peculiarities in the form of the casting required, very difficult to make properly. In other cases also of undercut and complex work, divisible patterns are needed, although no true cores are requisite.

The following, taken from Holtzapffel's "Mechanical Manipulation," forms the best possible illustration of a two-part pattern, and also the method of arranging a false core requiring no core box to be specially constructed for its formation.

The pattern, of which half is shaded to show distinctly the two separate parts, is that of a large pulley or sheave, and it is evident that such a pattern could not be removed unless some such arrangement as that described were made use of. The flask A, being placed on a board, is filled with sand and the pattern imbedded in it. The sand is then carefully removed to the line *a*, and being smoothed is dusted with brick dust or other fine and

dry parting material. This is always done when the mould will require to be separated at any given part, as the two portions are thus prevented from sticking together. Some more sand is then thrown in and rammed tolerably hard to the level of *b*. This forms a rind of false core, and is now itself well dusted and lastly covered by the remaining sand, a runner or channel having been arranged to guide the fluid metal. To remove the pattern, B is lifted off, and the sand will part on the line *b*, above the false core, and as no part of the pattern that is undercut is buried, and the upper half of the pattern itself separates from the lower, it may be removed. The flask is then replaced, a board laid upon it and

FIG. 9



the whole reversed, when upon being opened the remaining half pattern can be similarly removed. The runner is then carefully made to form a branch with the other, the second board added, and the whole clamped together and set on end ready for pouring.

Another method of forming a core is sometimes practised in which the pattern itself may be made to take the place of the core box. This is done when the mould is not quite such as to deliver its own core, but of so simple a character as not to need core prints. In this case the sand is rammed into the pattern, which is itself hollow when the finished work is intended so to be. The whole being then moulded as a solid work, the sand is pushed out of the hole and placed in position. In casting cup chucks for the lathe where two holes are eventually re quired of different diameters it is evident that either these holes may be made as one and a core made of the form shown in Fig. 10 by means of a box bored out to a similar shape, or two distinct cores must be made. This is easily avoided by pursuing a somewhat different process. The pattern is to be made exactly like the finished chuck, taking care that the hole which will have to be bored and tapped to fit the

mandril is a good deal smaller than the latter. A piece of soft brick is then to be filed up round as a short cylinder and fitted into the small end of the pattern from which it projects an inch. The whole is then to be placed as shown in Fig. 11, where this brick core is blackened. The lower and larger hollow will thus, if the latter is slightly tapered, deliver its own core, and after the flasks are parted and the pattern removed, the brick core is arranged in the place marked by its own print.

In making wooden patterns for moulding, let all sharp angles be avoided, and the various edges rounded off by the application of sandpaper. When the whole is smooth, blacklead and polish

FIG.12.

FIG.10.

FIG. 11

every part. You will find your account in this by the beautiful surface of the casting, especially if it be in brass or gun metal, as the former especially is often left in its rough state and dipped in acids instead of being turned or filed up bright, and when some parts are so turned and burnished and the rest dipped, the appearance is very beautiful, as seen in the varied and exquisite specimens of such work produced at Birmingham and elsewhere. In addition to the above precaution the patterns should always if possible taper slightly, to facilitate removal from the sand. Fig. 12 shows the pattern of chuck already alluded to, thus tapered inside and out, the taper exaggerated however, that it may be more distinctly noticed. The flasks in Fig. 11 would of course have to be inverted in pouring, else the core would fall from its place. Where possible however, the flasks are stood on end, and the moulds filled by runners or channels connected with the openings in these iron boxes seen in Fig. 1 of this series. There are a vast number of practices relative to moulding and pouring large

castings which would be out of place here, but a visit to any good foundry is highly interesting and will give many a hint to the amateur, while the pouring some work of real magnitude is a sight worth any trouble. Among the "Notes and Queries" of the "English Mechanic" has been asked a question relative to constructing furnaces for small operations in founding metal. There is a furnace made by Griffin and Co., of Garrick-street, Covent-garden, which is exactly suited for such work. It is compact, cleanly, burning spirit for fuel, and is in fact a table furnace of extraordinary power. The inventor says of it:—"It produces neither smoke nor soot, nor ill odours; it is so compact that it may stand on a tea-tray while melting eighty ounces of iron, and it requires no chimney. The guinea furnace will melt a pound of cast iron in twenty-five minutes at a cost of 3d. for oil. The guinea and a-half furnace will melt in sixty minutes five pounds of iron at a cost of 9d." The following detailed description of this furnace and method of using it is copied from "Griffin's Circular," in that wondrous catalogue and handbook, "Chemical Handicraft":—

Oil Lamp Furnace for Melting Metals at a White Heat.

"*Description of the Apparatus.*—The Oil Lamp Furnace is represented in perspective by Fig. 13, and in section by Fig. 14. It consists of a wick holder, an oil reservoir, and a fire-clay furnace. To these must be added, a blowing machine for the supply of atmospheric air.

"The oil reservoir is represented at letter *a*. It is made of japanned tinplate, mounted on iron legs, and fitted with a brass stopcock and delivery tube. Its capacity is a little more than a quart. The wick holder is represented at letter *b*, and the upper surface of it by the separate figure *c*. The wick holder and the oil reservoir are consequently detached. *d* is a tube which brings oil from the funnel *e*, and *f* is a tube to be placed in connection with the blowing apparatus. The wick holder contains three concentric wicks, placed round the multiple blowpipe *c*, which is in communication with the blowing tube *f*.

"The crucible furnace consists of the following parts :—*g* is an iron tripod ; *h* is a flue for collecting and directing the flame.

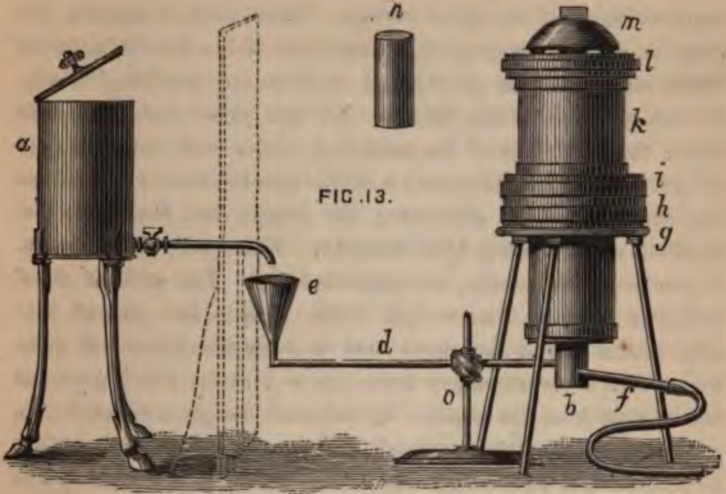


FIG. 13.

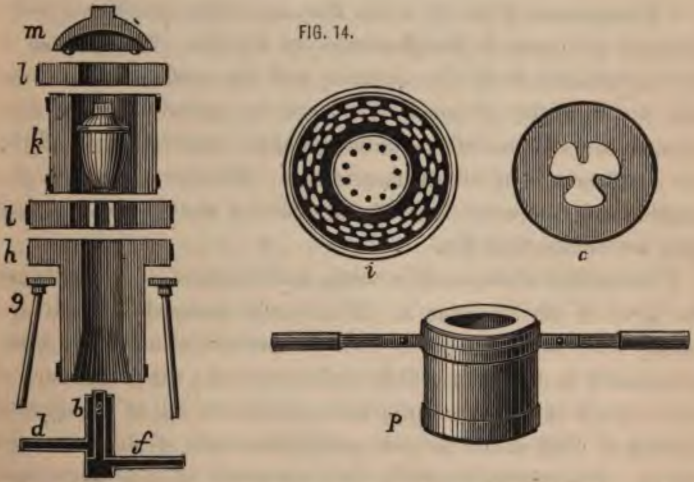


FIG. 14.

This flue is of such a width, that when the wick holder *b* is pushed up into it until the top of the wick is level with the top of the

clay cone, there remains a clear air space of about $\frac{1}{8}$in. all round between the wick holder and the cylindrical walls of the flue. *i* represents a fire-clay grate, having three tongues, shown by *i*, the separate figure of its upper surface. These tongues support the crucible, without stopping the rising flame. *k* is a fire-clay cylinder which rests upon the grate *i*, and encloses the crucible, forming, in fact, the body of the furnace. Of this piece there are three sizes: the smallest is of 3in. bore, and works with crucibles that do not exceed $2\frac{3}{4}$in. diameter; a middle size 4in. bore, for crucibles not exceeding $3\frac{1}{2}$in. diameter; the largest size, 5in. bore, for crucibles not exceeding $4\frac{3}{4}$in. diameter. This piece, being heavy, is provided with handles, as represented at *p*. The walls of these cylinders are from 1in. to $1\frac{1}{2}$in. thick. *l* is a flat plate of fire-clay, with a hole in the centre used to cover the cylinder *k*, so as to act like a reverberatory dome; *m* is a cover which prevents loss of heat from the crucible by radiation, but gives egress to the gaseous products of the combustion of the oil; *n* is an extinguisher to put over the wick holder when an operation is ended; and *o* is a support for the wick holder. No chimney is required.

"*Management of the Oil Lamp Furnace.*—The apparatus is to be arranged for use as it is represented by Fig. 13. The cylinder *k* is to be selected to fit the crucibles, and the crucible of a size to suit the quantity of metal that is to be melted. 1lb. of iron requires the smallest of the three cylinders described above, $1\frac{1}{2}$lb. the middle size, and 5lb. the largest size. The airway between the crucible and the inner walls of the cylinder should never exceed $\frac{1}{4}$in., nor be less than $\frac{1}{8}$in.

"The cotton wicks must be clean, and be trimmed a little below the level of the blowpipe *c*. If properly managed they do not readily burn away, but can be used for several fusions. The reservoir should be filled with oil for each operation; the proper sort of oil for use is the more volatile kind of mineral oil, of the specific gravity of ·750, which is now easily procurable at about 3s. per gallon. The variety known by the commercial name of turpenzine answers well; the combustion of a quart of this oil, costing ninepence, gives heat sufficient to melt 5lb. of cast iron. Probably the

lighter kinds of paraffin oil may be suitable, but I have not had an opportunity of trying them. Liquids of the alcohol class, spirits of wine, and pyroxylic spirit can be used ; but they are less effective and more expensive than turpentine. Care must be taken not to spill the oil on the table or floor, and not to decant it carelessly in the neighbourhood of a light, because atmospheric air strongly charged with the vapour of these light oils is explosive. When the oil is burnt in the furnace, in the manner described below, there is no danger. During an operation a wooden screen, as represented by the dotted lines in Fig. 13, should be placed between the oil reservoir and the furnace, to prevent the vaporisation of the oil by radiant heat.

"As the wick holder *b* and supply pipe *d* contain only about one fluid ounce of oil, the oil must be run continuously, during a fusion, from the reservoir *a* into the funnel *e*, in order that the cotton may be always flooded. The success of the fusion depends upon the due supply of oil, to which point the operator must pay attention. At the commencement of a fusion the oil must be run from the reservoir until the surface of the oil in the funnel has a diameter of about an inch. The wicks will then be flooded, and a light may be applied, and a gentle blast of air then set on. The oil immediately sinks into the funnel, and the stopcock must be opened, and so regulated as to keep the oil barely visible at the bottom of the funnel. If too much oil is supplied it immediately rises in the funnel, and simultaneously overflows the wick holder. Too much vapour is then thrown into the furnace, and the heat is immediately lowered, especially at the beginning of an operation, before the fire-clay portions of the furnace are well heated. If, on the contrary, too little oil is supplied, the wicks burn, and the operation is spoilt. The demand of the wick holder for oil depends upon the condition of the furnace and the character of the fusion in progress. When the lamp is newly lighted and the furnace cold, the oil should be passed slowly, in distinct drops ; but as the furnace becomes hot, the rapidity of the supply of drops should be increased ; and, finally, when the furnace is at a white heat, the oil should be supplied in a thin continuous stream. When the fusion

to be effected is that of only a small quantity of metal, such as 1lb. of iron, a rapid supply of drops of oil is sufficient, even to the close of the operation. At that rate the burner consumes about $1\frac{1}{4}$ pint of oil in an hour. When the fusion to be effected is that of 4lb. or 5lb. of iron, and the large furnace is in action and has been brought to a white heat, the supply of oil must, as stated above, be in a thin continuous stream, and the operation will then consume 2 pints of oil in the hour. And here it requires remark that, with that continuous supply, when the furnace is large and at a white heat, the oil does not rise in the funnel, being instantaneously converted into gas at the mouth of the burner, and thrown up in that state into the furnace for combustion. The operation, indeed, consists, at that point, of a rapid distillation of oil gas, which is immediately burnt, in the presence of air supplied at a suitable pressure by a dozen blowpipes, in effective contact with the crucible to be heated.

"The flame produced in this furnace is as clear as that produced by an explosive mixture of air and coal gas. It is perfectly free from smoke, and the unconsumed vapours which occasionall escape with the gaseous products of the combustion are even les unpleasant to smell and to breathe in than are those which are usually disengaged by a blast gas furnace, or by an ordinary lamp fed with pyroxylic spirit.

"The contents of a crucible under ignition in this furnace can at any moment be readily examined, it being only necessary to remove the pieces *l* and *m* with tongs, and to lift the cover of the crucible, during which the action of the furnace is not to be interrupted.

"When the operation is finished the blast is stopped, the stopcock is turned off, the oil reservoir is removed, the wick holder is lowered on the support *o*, withdrawn from the furnace, and covered with the extinguisher *n*. The quantity of oil which then remains in the lamp is about one fluid ounce.

"*Power of the Oil Lamp Furnace.*—The furnace being cold when an operation is commeneed, it will melt 1lb. of cast iron in twenty, five minutes, $1\frac{1}{2}$lb. in thirty minutes, 4lb. in forty-five minutes- aud 5lb. in sixty minutes. When the furnace is hot, such fusions

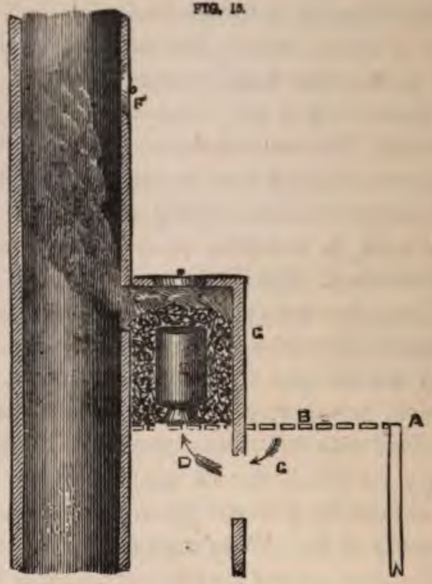
can be effected in much less time—for example, 1lb. of iron in fifteen minutes. It need scarcely be added that small quantities of gold, silver, copper, brass, German silver, &c., can be melted with great ease, and that all the chemical processes that are commonly effected in platinum and porcelain crucibles can be promptly accomplished in the smallest cylinder of this furnace; and in the case of platinum vessels, with this special advantage, that the oil gas is free from those sulphurous compounds, the presence of which in coal gas frequently causes damage to the crucibles.

"*Requisite Blowing Power.*—The size of the blowing machine required to develop the fusing power of this oil lamp furnace depends on the amount of heat required, or the weight of metal that is to be fused. For ordinary chemical operations with platinum and porcelain crucibles, and even for the fusion of 1lb. of cast iron in clay or plumbago crucibles, a blowing power equal to that of a glassblower's table is sufficient, provided the blast it gives is uniform and constant. But the fusion of masses of iron weighing 4lb. or 5lb. demands a more powerful blower, such as is commonly used in chemical laboratories for the supply of air to blast furnaces when fed by gas or coke. The highest power of the oil lamp furnace depends, indeed, upon the power of the blowing machine that is to be used with it. Much more than 5lb. of iron can be melted by the gas which this oil lamp is capable of supplying, provided a sufficiently powerful blowing machine supplies the requisite quantity of air. When more than a quart of oil is to be rapidly distilled into gas, and the whole of the gas is to be instantly burned with oxygen, it is evident that effective work demands a large and prompt supply of air.

"*Cost of the Oil Lamp Furnace.*—As in all practical matters of this sort, the *cost* is a main question, it may be useful to state that the price of this apparatus, complete, without the blowing machine, but including every other portion necessary for heating crucibles up to the size sufficient to fuse 1lb. of cast iron, is *one guinea;* and with the extra furnace-pieces for crucibles suitable for 5lb. of iron, or any intermediate quantity, the cost is *a guinea and a half.*"

The only drawback to the above and similar table furnaces is the necessity for a pair of double bellows arranged in convenient form. This, of course, raises the estimate by the cost of such addition. Brass may be melted without a blast in what is called an air furnace, and any reader who can command a chimney in some outhouse or who can construct one, may practise founding this metal. Be it known further that it is not easy to manage iron

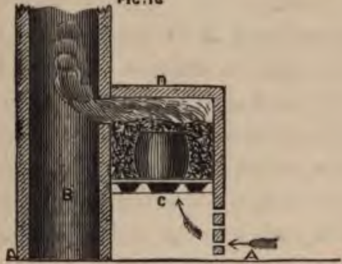
FIG. 15.



founding, although the process is similar to that used for other metals. Iron should be fused in larger quantities than required generally by the amateur, and then a proper furnace and much practical skill are requisite to produce good effects. In point of fact, "Old File" has had his best teeth destroyed by being compelled to perfect the form of an amateur's casting, which was pinny and honeycombed and full of slag; hence he warns his brother files to strike at once if any attempt should be made to induce them to perform a similar operation. The air furnace may be thus constructed. Let E (Fig. 15) be the available chimney. Dig out in

front of it an ash pit D C, A being the level of the floor. This may be from two feet, measuring the length through C and D, by eighteen inches in the other direction, with an allowance in addition for the thickness of two brick walls. The first of these nearest to A is to be brought up to the level of the floor. It may be one brick (lengthwise) in thickness, because you can then have the full width of a brick at the top to support B, the grating which conveys air to the furnace. The next or inner wall G is carried up from the bottom of the ash pit to the level of the floor, where the brickwork is arranged to form a resting-place on both sides to support the opposite side of the before-named grating, and the firebars above D. It is then again carried up about ten inches or a foot, forming the fire receptacle, which part is eventually covered by a tile of iron or stone. This firegrate, which is the

FIG. 16



actual furnace, is now to be lined either with firebrick set in fireclay —or lined with the latter, which may be obtained as a powder requiring only to be mixed with water. This lining will reduce the size of the furnace to eight or nine inches diameter, which is ample for any purpose. The opening into the chimney may be six inches square or less.

Such a furnace thus readily constructed is the most useful that the amateur can possess. It must be used chiefly with coke, and will suffice for brazing if the article is so arranged as not to touch the fuel, which may be effected by laying it upon a grating of iron wire. For this and some other purposes (mechanical or chemical, as the case may he) an extra cover or rather stopper can

be arranged in front at G. In the next figure the same principle is carried out without sinking the ash pit, the whole being built up from A, the floor level. This, however, raises the cover of the firegrate rather too high for the convenient extraction of the crucibles. There are numbers of portable furnaces constructed of iron on precisely the same principle, requiring only an iron chimney to increase the draught. These are lined with Stourbridge clay, and answer for many purposes of the amateur.

FORGING.

The operations of filing, planing, and otherwise finishing by cutting tools the castings obtained must give place for the present to a brief description of the method of shaping articles with the hammer and the forge.

This, be it remembered, is as much an art as casting, if not more so, and although the smith appears to fashion articles of various forms with the utmost ease, and with tools that often look clumsy and imperfect, the amateur will soon find that practice and skill, united with a perfect knowledge of the *nature* of the material in which he has to work, are essential even to *moderate* success.

The *visible* difference between cast and wrought iron is the granular appearance of the former when broken, and the evidently fibrous condition of the other. It is indeed this peculiarity of structure that renders the first brittle and the other tough. A piece of thin cast iron which has not been subjected to a process of annealing is almost as brittle as glass, and even a bar an inch or two in diameter can readily be broken in any required spot if it be first notched with a file, and then suddenly struck with a hammer. There is, however, a process by which, while this brittleness is only partially destroyed, the nature of cast iron may be so altered and improved as to allow of its being filed or turned with greatly increased facility.

In this state it is called malleable cast iron, and is extensively used in the manufacture of lathes, sewing machines, and other

articles of that class. The method of effecting this, which is after all a superior kind of annealing process, is stated by Holtzapffel to be as follows, and is introduced here, not because it is likely the amateur will himself pursue it, but rather to show how scientific knowledge avails in overcoming the natural defects of any material. It is true that some very important processes in the arts and manufactures have originated in chance discoveries; but even in such cases accident has never availed to develop and bring such discoveries to a practical result; and he who, by patient investigation of cause and effect, turns such accidents to advantage, is as truly an inventor as he who by careful experiment and well-directed study brings to a practical conclusion some idea originated in his own brain. The following process is evidently based upon sound chemical principles skilfully applied :—

"The malleable iron castings are at the opposite extreme of the scale, and are rendered extremely soft by the abstraction of their carbon, whereby they are nearly reduced to the condition of pure malleable iron, but without the fibre which is due to the hammering and rolling employed at the forge. The malleable iron castings are made from the rich Cumberland iron, and are at first as brittle as glass or hardened steel. They are enclosed in boxes of suitable size, and surrounded with pounded ironstone or some of the metallic oxides, as the scales from the common forge, or with lime and various other absorbents of carbon together or separate. The cases, which are sometimes as large as barrels, are luted, rolled into the ovens or furnaces, and submitted to a good heat for about five days, and are then allowed to cool very gradually within the furnaces. The time and other circumstances determine the depth of the effect. Thin pieces become malleable entirely through, and are then readily bent and may be even slightly forged. Cast iron nails and tacks thus treated admit of being clenched; thicker pieces retain a central portion of cast iron, but in a softened state and not so brittle as at first. On sawing them through, the skin or coat of soft iron is perfectly distinct from the remainder."

It might be naturally supposed that all professional ironfounders must be acquainted with the process here described; but this is by

no means the case, and a country founder stopped the writer only a few days since to ask information respecting this malleable iron, which he believed to be a "new invention" hence the advice already given to have castiags done at some well-established foundry, even at an additional cost for carriage, is not without reason.

It is evident from the above remarks that iron in its ordinary condition as cast metal is useless for the purpose of the smith, who has to shape with the hammer and weld his work. But there is also another matter of importance to be considered—namely, that cast iron is very fusible, while on the other hand wrought iron, as it is called, which has undergone the process of puddling for abstraction of its carbon, and the grains of which have by rolling and hammering become elongated into fibres, is almost and practically *quite* infusible, burning away with emission of sparks and scintillations at a heat slightly above that required for welding, and at that temperature by union with the oxygen of the atmosphere becoming changed into an oxide.

Confining our present remarks, therefore, to wrought iron, it may be stated that there is a good deal of difference in the qualities of different specimens. Some will weld easily and others scarcely at all. Some will break up under the hammer at a red heat, while others may be hammered till cold, and a third will work well at various heats, but when cold will break like cast iron, exhibiting a granular fracture It is not easy to say which of such specimens are defective, because, as Mr. Solly has remarked, the iron which has one peculiarity may be excellent for one purpose, while that which exhibits other conditions may be equally so for other purposes, so that in fact all alike become available in manufactures in which this metal is required, and the above variations of quality render it even more valuable than if all specimens were precisely similar.

The amateur's forging operations will for the most part be confined to small articles not requiring the use of the sledge hammer, and for which small rods of iron of square, oblong, or circular section will be required not generally larger than ½in. in diameter, and frequently less.

A small portable forge, the price of which varies from 50s. to £5 or £6, according to size and finish and power of bellows, will be by far more convenient for such light work than a regular forge built for the purpose, though sometimes, where an available outhouse exists, the latter may be raised by the amateur himself of any rough materials at hand, the hearth alone requiring to be made of firebrick. A small pair of bellows for such a forge can be purchased for a sovereign, and little ingenuity is required for fixing them properly.

It must be remembered that a tuyere, or, as it is generally called, a tew iron, is necessary to prevent the end of the nozzle of the bellows from burning; it is of cast iron, and heavy, with a conical hole through it—the square end is to be placed next to the hearth, and the nozzle of the bellows inserted from behind. The usual arrangement of the rocking staff or handle by which the bellows are worked can be seen at any forge, and need not be described here. The tools required by the amateur may be well reduced to a very few. Discarding the heavy sledge as requiring an assistant, let him purchase two striking hammers, or hand hammers, the one very light for small articles, the other rather heavier, which is to be used in reducing a thick piece to a smaller size, or "drawing down," as it is called; and let the one or the other be in use as often as possible—now hammering cold iron, now hot—to get the hand accustomed to the feel of this tool and to the use of the anvil, which should weigh from 1cwt. to 2cwt., and be mounted on a good heavy block of wood sawn from the end of a tree.

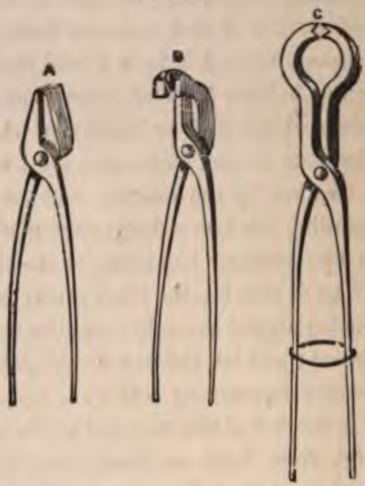
To hold short pieces, various sizes and forms of tongs will be required of the patterns A B C, Fig. 17.

The first of these are the ordinary smith's tongs, which are made light or heavy, and to shut close or remain partially open when the handles meet, according to the size and weight of metal to be worked. The second are the tongs used by Sheffield cutlers and others; these permit part of the bar held to come up towards the hand, while the hook prevents it from being shaken out of hold by the jar of hammering. This form is very suitable for the amateur, who nevertheless should practice considerably with the

more common form of tongs. The third pattern C is intended for holding short bolts or other similarly-shaped pieces, the heads of which will fall inside, the curved part enabling the shank to be closely grasped.*

A ring (Fig. C) is very often slipped over the handles of the smith's tongs, by which their grasp is insured without the pressure of the hand otherwise needed, which, being required to be continually kept up, becomes rather tedious and difficult to those not thoroughly used to the work. There are other tools used by the

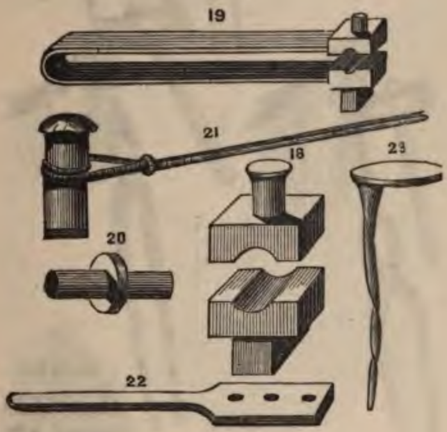
FIG. 17.



regular workman to assist in more perfectly shaping the work in hand. These mostly require the aid of an assistant, and are therefore not so serviceable to the amateur as they otherwise would be; they are called swages, and are made in pairs, as Fig. 18. It is possible, indeed, to use the small sizes singlehanded, as the lower swage fits a square hole in the anvil, so that the upper one can be held in the left hand, but in this case the small bolt or other article has to be laid in position, while hot from the fire, upon the bottom

* The notch in these tongs should be in the ends, not in the sides as here drawn.

tool, and released quickly from the tongs, and is thus apt to shift from its place or drop out of the swage. The spring swages correct the above drawback: they are represented in the next figure, and will be found very convenient; it would, however, be an improvement to make the same spring serve for several sizes of swage tools by inserting its ends in square mortises in the latter, or otherwise connecting the two. A good deal of lathe and file work will be saved by having some few of the swage tools made for rounding and heading small work, and one pair at least should be of such pattern as will produce a head or flange in the middle of a bar, as shown in Fig. 20.



In addition to the above, the amateur will need two or three chisels and punches of different sizes; one of the former is always attached to the anvil, the iron to be cut being placed across it, and struck with the hammer till nearly severed, after which its end is inserted in a hole in the anvil or elsewhere and broken off. Both chisels and punches to be used separately are generally held in hazel rods, Fig. 21. These are wetted and held over the fire till the heated sap renders them soft and pliable, when they receive two or three twists, and are then wound round the tool and fastened by a ring as shown. The wooden handles thus made,

FIG.24.

FIG.27.

FIG.28.

FIG.30

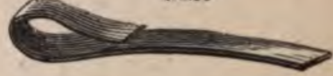


FIG.29


FIG.26

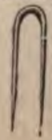


FIG.25.

FIG. 34.

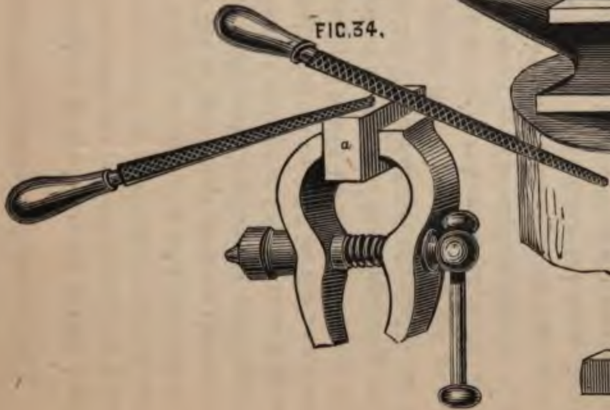


FIG 32.

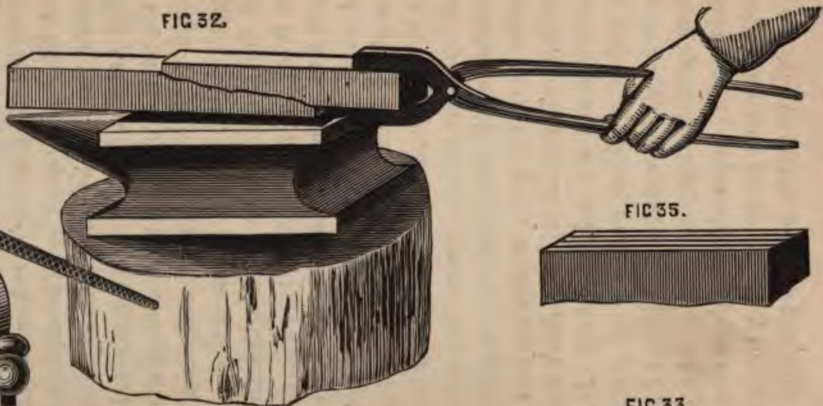


FIG 35.

FIG 33.

FIG. 31.

clumsy as they may appear to the looker on, answer better than if of metal, because they prevent the hand from being jarred by the shock of the hammer, and in addition are easily and quickly removed when it may be necessary to take the chisel or punch again to the forge fire or grindstone to have the edge renewed, which owing to the rough work they have to perform is a process often required. The first attempt at forging should be made on a bar of iron sufficiently long to be held in the hand without the aid of the smith's tongs, as it will be far more easy in this case to work it to the required form. The best beginning will be the attempt to forge a nail. The bar of iron of suitable size (nail rod) is to be taken of sufficient length not to need the tongs, and the end is to be heated to a bright red, or rather white heat. It is then to be laid on the anvil so as to slightly overlap it, and it is not to lie flat but is to be a little raised at the end by which it is held. The hammer is then to be made fall upon it, where the edge of the anvil is underneath it, so that the hammer itself will make a small angle with the surface of the anvil. After a blow has been given, the hand is to cause the iron to take a quarter turn, and this is at first very difficult, the failure in this respect which at first is almost certain to occur, causing the metal to assume a twisted form. This difficulty can only be overcome by continual practice, but it will be referred to again presently. After two blows given as above the iron is to be *drawn back* a little, and two more blows given, and so on until the metal is reduced to a point, and has taken a conical form. The rod is then placed across the fixed chisel on the anvil, and a blow given to cut it *nearly* off at the desired place, the point is then inserted in one of the holes in the heading tool, Fig. 22 (which is faced with steel, if not made of that material), and the nail twisted off. It is now placed, with its point projecting below, over one of the holes in the anvil, always made for that purpose, and the head formed by hammering on and thus spreading the part which stood up above the header. All this is in reality, to practised hands, a very rapid process, and always easily completed by once heating the iron. Fig 23 (I hope the engravers will be careful !) is the probable result of the ama-

teur's first attempt—head on one side, no point, twisted, clumsy, and lastly useless, for, probably having been over-heated, the iron has been burnt and become brittle.

We shall get all this right by and by, so do not be disheartened. "Old File" made just such a beauty when first he attempted to turn smith; he is an old hand now, and can make a tidy nail with speed and ease.

Let us now see what is the matter with the nail illustrated. First, it is supposed to be burnt at the end. The sign of iron beginning to burn in the forge is the appearance of bright sparks, distinguishable at once from those of the coal by their brilliance. If these begin to appear, the tip of the iron will crumble away; it must therefore be cut off at once, before the shaping of the nail is attempted. But this is wasteful, and bad work, and the tyro must therefore withdraw the iron from the fire at a white heat just below welding and below burning. The twisting of the shank of the nail is due to the unpractised hand being unable to turn the bar a true quarter turn between the blows of the hammer, it is rolled over on the anvil now too much and then too little, or else the centre of the *pane* of the hammer falls untruly. It is a good plan to use square bars instead of round, and to practise with them only slightly or not at all heated; it will be evident then at once whether the bar lies truly on one of its faces. It is never necessary to turn the rod over completely and to hammer its four faces, because when the hammer strikes the one that is uppermost, the anvil, by the mechanical law of reaction strikes the lower face with equal force. Fig. 24 will perhaps assist in explaining the position of a bar to be drawn down to a smaller size, and also that of the hammer. The face of the latter is more or less rounded, and the centre of this should fall on the centre of the bar at every blow. In the sketch given of the finished nail the head is shown on one side. This arises from the iron not being drawn down sufficiently to allow it to pass far enough through the hole selected in the header. Thus it stands up too high, and is first bent over, Fig. 25, and then the side and not the end comes under the action of the hammer. A very little projection above

the heading tool is required to make a head, and the latter must be formed neatly with light blows given as perpendicularly as possible, and centrally as regards the end of the piece, which is thus spread equally on all sides. Nails being always useful, as are also spikes and stay nails, it is worth while to make several of them, and it is astonishing how quickly the hand and hammer become acquainted and combine to follow the eye, so that by the time a couple of dozen nails have been completed much of the primary difficulty will be found to have vanished. Let the next work be a staple, Fig. 26, which will introduce the novice to the manipulation of the tongs. Draw down and point a bar as before, then cut it off at the required distance, which is such as apparently to leave the piece too short, because in forming the second point by drawing down, it will be lengthened. Take up the piece already pointed at one end in the small tongs, and heat it where cut off. Now draw down this end to match the other. In doing this a new difficulty will arise, and probably one blow will hit the tongs, and the next may very likely hit the piece out of them. Fig. 27 shows the fault in an exaggerated degree that causes the iron to fly out of the tongs. It is evident that there is no support where the blow falls, and the jar therefore is entirely upon the tongs. In drawing down, Fig. 28, the anvil supports the piece, and also in Fig. 29, which shows the iron lying flat, which is the position it may assume in finishing off the point; and thus placed, the force of the blow is also communicated to the anvil, which is so heavy that it does not itself move, but by the reaction already alluded to, which is due to its inherent elasticity, causes the blow to take effect upon the soft iron. This reaction is of great service to the blacksmith, who when working rapidly may be observed frequently to strike the anvil purposely between the blows which he is giving to his work, especially when he is forging with the assistance of the striker, or one using the sledge. In this way he not only keeps time, but the hand hammer rebounding of its own accord is raised for the succeeding stroke, and an inappreciable effort only is required to lift it on the part of the smith who wields it. The amateur should therefore experiment on this *modus operandi*, and he will find the use of it even

in single-handed forgings of work of small dimensions; rapidity is thereby insured, and the iron is shaped before it has time to lose its heat. It is hardly necessary to add that to finish the staple the iron has to be heated in the middle and bent over the nose of the anvil—an easy operation enough, yet one that requires the tongs to be well handled and the iron well directed, else the piece will be knocked out of the former upon the floor. To thicken a piece of iron at any particular part, where the increase of substance is not required to be considerable, the bar is heated at the given point, and struck upon the end while it is held upright upon the anvil. This will cause the heated and softened part to bulge out, forming the enlargement required. In this way a flange in the centre of the bar may be begun, to be finished between swages, as shown in a previous figure; but if this flange is to be larger it is better to weld or shrink on a ring of the requisite diameter and thickness. To do this it is only necessary to make such a ring with the hole just large enough not to quite admit the bar. The ring is then to be heated, which, by expanding it, will allow the bar to enter, and after quenching in cold water the ring will be found immovably fixed in its place, and the whole may be either swaged up, or turned in the lathe. An attempt should now be made at welding two pieces of iron together, an operation often very ineffectually done even by experienced blacksmiths. It being, however, more difficult to manage two distinct bars than one, the beginner may first bend a piece of iron into the form of a pear-shaped ring, Fig. 30. Heat this in the fire until sparks begin to arise, sprinkling some sand upon the spot at which junction is to be effected before the above excessive heat is arrived at. This forms a glaze upon the part, which not only retards the burning of the metal, but in addition prevents oxidation, and the formation of those black scales which lie in such plenty around the anvil, and which hinder an effective weld from taking place. Withdraw the bar quickly from the forge, striking it against the anvil to detach any such chance scales, and then with a few light blows the parts will be firmly united. This is simply an operation requiring care and speed; you must literally "strike while the iron is hot," but nevertheless

steadily and coolly, with well-directed blows, and it is strongly advised never to omit the sand in this process. It is better on the latter account to leave the loop slightly open at first, so that the sand may fall within the joint, although this is not absolutely essential. The loop thus made should be as strong where welded as in any other part; it will therefore be a good test to reheat it and shape it on the point of the anvil into a more perfect ring, when if badly welded the joint is sure to open and betray the unskilfulness of the workman. Supposing, however, that success has attended this first attempt, which will probably be the case if the directions given have been carefully attended to, it will be well to practise on two distinct pieces, one at least of which should be held in the tongs.

The two bars to be welded must first be prepared by heating to a bright red, and the parts to be united flattened down or roughly scarfed with the hammer, presenting somewhat the appearance of a rude flight of steps, Fig. 31. One (or both, if short) must now be taken up, each with separate tongs in the latter case, and brought to a welding heat at the same time. It is necessary to this end to expose both as equally as possible to the hottest part of the fire, moving and turning them about to equalise the heat, or else one will be burning while the other is only red. When you find by inspection that both are white hot, sprinkle sand upon them as before and see that they are in the position to be firmly seized in a moment and placed on the anvil in a proper direction. Supposing the assistance of a striker is not to be obtained, the shorter piece when withdrawn must, after being rapidly place in position, be held by the contact of the other till by a single blow of the hammer the two are made to adhere, after which, by further blows the whole is to be consolidated, the bar (now firmly united in one piece) being turned about as the operation proceeds, so as to expose all parts alike to the action of the hammer. The position of the scarfed joint before the welding takes place is shown in Fig. 32, the tongs being supposed to have been just withdrawn from the under piece. Some little practice is required to insure a perfect union, because the management of a pair of tongs in each

hand is rather awkward at first, but if the iron is sufficiently hot a slight union takes place as soon as the pieces are laid in position, and the left-hand tongs being instantly dropped the pieces will remain in contact till the first blow unites them more completely. If the joint is long it cannot be completed at one heat, and an inch or two having been united the whole must be returned to the fire, the same precautions being followed each time it is withdrawn in regard to detaching scale by striking the tongs or bar against the anvil, sanding, and so forth. If, as is probable, the previous operation has thinned the bar at the point of union, let it be struck endwise to bulge it out or "upset" it, as it is termed, and then carefully hammered again into the shape required, round, square, or otherwise.

Fig. 33 shows how in a few cases the second pair of tongs may be dispensed with, a plan used in welding steel into an iron socket. The split piece retains the other in place while both are in process of heating and welding, and the latter operation is very easily and quickly completed. In this way many cutting tools, hatchets, for instance, are made, in which the edge to be sharpened is central. If, however, like a carpenter's chisel, it is bevelled one side only, so that the edge is on the back or front, the steel cannot be thus inserted, but must be welded upon the outer surface of the iron. In both cases borax is to be used instead of sand, as it greatly facilitates the union of iron to steel —indeed it is hardly possible to accomplish such work without the aid of this salt. It is also necessary to remember that as steel will not bear the same degree of heat as iron, the latter must be placed first in the fire, and when this approaches the required temperature the steel is to be introduced and both returned to the forge, and when the iron is at welding heat the two may be worked together and a sound junction effected, so that both may be afterwards hammered down to a thin edge with certainty of the steel remaining in its place in the centre. In practice, however, the steel of a hatchet is not thus wholly encased in iron, the latter being chiefly confined to the upper part or eye. The steel is consequently allowed to project considerably and is then spread out

by heating and hammering so as to form the edge and thinner part of the blade.

CASE-HARDENING, HARDENING, AND TEMPERING.

It is impossible and unnecessary in a brief account of the work of the smithy, which is solely intended for the instruction of amateurs, to enter further into the manifold details of the art. We shall now, therefore, pass on to other matters connected with the working of forged metals — case-hardening, hardening, and tempering.

The surface of iron may be superficially converted into steel by enclosing it in an iron box with shreds of leather, bone dust, or similar animal matters, and exposing the whole to a red heat for some time, varying from two to four hours, according to the depth of steel required. The pieces thus cased in steel are then chilled in oil and will take an excellent polish. A more rapid method of case-hardening is often employed, the effect of which is, however, exceedingly superficial. The iron is to be heated to redness, and rubbed with the salt called prussiate of potash, or rolled in the same reduced to powder; it is then re-heated and quenched. The surface is thus rendered excessively hard, while, as in all instances of case-hardening, the central portions retain the toughness of the ordinary forged metal, or that of the casting, if such has been treated in this way.

To harden and temper steel tools of various sizes and forms, two slightly different methods are used. The first is extensively practised by blacksmiths in making the chisels and punches required in their work. The second is more suitable for small tools, such as drills, and the cutters and similar articles used by the ornamental turner and carver. By the first method the steel, after being shaped to the required form, is heated to a bright red, and the edge dipped or quenched in cold water. Being immediately withdrawn, the tool is rubbed quickly on the stone hearth of the forge to brighten it, and the colours caused by oxidation of its surface are

watched, and when a deep orange or the first tinge of blue is reached, the tool is again plunged and moved about in the water till quite cold. In the smaller tools the above process cannot be carried out, because the mass is insufficient to retain the necessary heat after the edge has been dipped. Such articles are, therefore, after being heated, quenched entirely, and having been rubbed bright, are laid upon a hot iron plate, or otherwise carefully raised to the required temperature, and quenched as before.

If extreme hardness is not so much required as that which allows a degree of elasticity to the tool, it is better to use oil instead of water, both for quenching before and after tempering. Small watchmaker's drills and broaches are nearly always so managed, the first being generally heated in a candle flame, and afterwards plunged into the grease. If actual spring in the article is required, it is quenched first in oil, and then held again over the fire until the film of oil lights and burns away. It is thus that watch-springs are tempered. It is essential in all cases to remove the scale caused by forging before tempering, as this forms a crust upon the surface, preventing the water or oil from taking full and instantaneous effect upon the parts thus protected. It is better, therefore, after careful forging, to continue the hammering till the metal is nearly cold, to finish it upon the grindstone, and after thus rendering its surface smooth and bright, raise it slowly to the heat required, which is never to exceed a full red, because the lower the temperature which will produce the desired effect, the better will be the edge produced.

Softening Steel.—This is a process which may probably be sometimes required by the amateur who wishes to turn this metal in the lathe. It may be effected by enclosing the article in an iron box, or in a crucible with charcoal powder, and after it has been made red-hot, allowing it to remain in the fire till the latter has gone out. A forge fire is not needed, and, indeed, it is better in hardening and tempering, as well as in thus softening steel, to make use of a fire without a blast; but the fuel should be coke or charcoal.

Filing.—This, although one of the ordinary operations of the blacksmith and general mechanic, is by no means universally well

done. Since the introduction of the planing machine it has not been so extensively needed, and, in consequence, few workmen have attained that peculiar aptitude of hand and eye so necessary for its exact performance. The file, whether considered as an abrading or cutting tool of many teeth, is well adapted for the work of reducing to a level the unequal surfaces of cast or wrought metal; but the natural movement of the hand and arm in using it militates against the accuracy of the work. A certain degree of training, therefore, becomes necessary, the nature of which will be here explained. Let *a*, Fig. 34, represent a piece of iron in the vice, the top edge of which is to be reduced to a level surface. At the beginning of the stroke of the file, the tool being held by the handle in the right hand, while the left is applied near its other end, the latter is supported by the work, and the unsupported part towards the handle has a downward tendency. At the middle of the stroke, the centre of the file being supported, the pressure on its ends becomes equal, and the tool assumes a level or horizontal position, but from this moment the pressure begins to predominate towards the point of the instrument, which is consequently depressed. Hence a kind of see-saw motion occurs, of which the iron to be filed is the fulcrum, and this becomes, in consequence, rounded at the top, the two edges being partially or wholly obliterated.

In addition to the above, another source of error lies in the fact of the arms turning as on a pivot at the shoulder joint, so that the movement of the hands naturally takes place in arcs of a circle instead of in the horizontal line. By constant practice it is possible to acquire the art nevertheless of keeping the course of the file level even on such a narrow edge as is here supposed to require dressing; and as precision of work can alone occur when this skill has been attained, no pains should be spared in the endeavour to acquire it. The writer believes that the surest method is to aim constantly at reducing the centre of the work, neglecting the edges, as if endeavouring to produce a concave surface. The latter, be it remembered, is actually possible, because a file, being generally thicker in the middle than it is at the ends, presents two

convex surfaces exactly adapted to the end in view. The work should be placed also at a proper height, about level with the chest, when the head slightly inclined will enable a good view to be had of the surface of the work as the filing proceeds. It is a very good test to draw-file the work now and then—that is, to use the file in a line at right angles to its breadth, or sideways. The cuts or scratches thus produced will consequently be in the direction of the length of the piece, as shown in Fig. 35. Then returning to the usual way of using the file, you will at once see by the marks made whether you are working too much on the edges or are succeeding in the attempt to touch chiefly the central part, thus keeping the edges sharp, which is the perfection of such work. If instead of a narrow bar it is necessary to have a wider piece, it will be less difficult to preserve the edges, because the file has more resting places or points of contact; but in this case there is danger of producing either a regular bevel in one direction only, or a succession of such bevels on the surface of the piece. The same advice may be given of making an attempt at producing a slight hollow in the centre of the work, which should be first attacked; but the strokes of the file may now with advantage be in all directions, lengthwise, across, and from corner to corner, a straight-edge being constantly at hand to test the accuracy of the operation as it proceeds. If it is required to level a thin plate of metal, it is often difficult to support it horizontally. If ¼in. thick the best plan is to lay it upon the workbench and drive round it a few small nails, keeping their heads below its level; if too thin for this it may be cemented with turners' cement to a block of wood as a support. Pieces of triangular or other section may be laid in similar recesses formed in a "filing block" of hard wood or lead, as the latter may be cast in a sand-bed in which the bar lies with that face downwards which is to be filed, and if this face is slightly pressed into the level bed of sand in which the casting is to be made, the required face will project above the general level of the lead, so as to admit of the action upon it of the file. In this way many peculiarly-formed articles may be firmly retained which could not easily be held in any other manner. Another

method of holding small thin pieces is to lay them on a support of wood and grasp the two in a hand-vice. The latter may now be fixed in the jaws of a tail-vice by its hinged or jointed extremity in such a position as to bring the surface of the work level, the latter can thus be filed as far as where it is held by the small vice, and afterwards shifted to enable the operator to work upon the part formerly thus held—many pieces of a curved form may be thus very readily filed on their flat surfaces. To protect the finished side from the teeth of the vice when the work is to be carried on upon other parts, it may be placed between pieces of lead or wood, of which false jaws are also made to fit within those of the vice.

It must not be forgotten that an old or partially-worn file is useless for brass and slmost useless for cast iron, while on wrought iron it may still answer. Hence for economy's sake files should first be used on the yellow metal or cast iron, and after they cease to cut freely, transferred to wrought metal.

To file up a square bar, first level one face by the aid of a straight-edge ; next, work on the sides, taking care they are rendered truly at right angles to the face first levelled ; and lastly, true the fourth side. In working thus, a gauge line can be drawn round the edge, measured from the face which was first attended to, by which the thickness will be insured correct, and the lower plane rendered parallel with the upper. In working to this line, however, the suggestions already given must be carefully attended to. Try to file the middle, not the edge, down to the line, and now and then run the file lengthwise instead of across the work. It will be a decided triumph if the bar when done will bear the test of square and straight-edge, "and no favour."

DRILLING.

Drilling is one of the most common of workshop operations, and there are several kinds of drill by which it is effected. Before going into details of these, however, we may observe that the main difficulty experienced is drilling straight through in the direction required. With the reciprocating drill, used with the stock against the breast, and worked with a bow, Figs. 36 and 37, or with the Archimedean drill, Fig. 38, it is next to impossible to see whether the tool is lying horizontally when the piece is being drilled, it being held in the vice as usual. To insure correctness it will be necessary, if practicable, to mark both sides, and drill half from each with a smaller drill than required, and then with a rimer or broach to enlarge and true the hole. But except for watch and clock work, and articles of a light description, these to-and-fro drills may be discarded and replaced by the new American twist drill, wherever practicable. This tool, made of all sizes, in sets, is equalled by none yet introduced ; but it requires a self-centering chuck, usually sold with it, and consequently a lathe head to carry it. The latter, however, is now found in all amateur workshops, and it will well repay the cost incurred to fit the above-named chuck to its mandril.

This drill, Fig 39*, properly ground does not throw out dust, but a clearly-cut, curled shaving, and leaves a perfectly smooth, round hole. The cutting power, however, of a drill is not dependent upon the twist of the shank, although in the present instance the edge formed by the meeting of the two twists or threads gives a peculiarly good form of point, and no drill has yet been introduced which rivals these lately imported from America. The following figures will render the matter clear, and enable the amateur to improve very considerably the tool usually purchased for the lathe or drill stock :—

Fig. 40 has the appearance of a sharp and good tool, but is

* The engraving of the tool is defective, giving the apperance of a broken drill with no point.

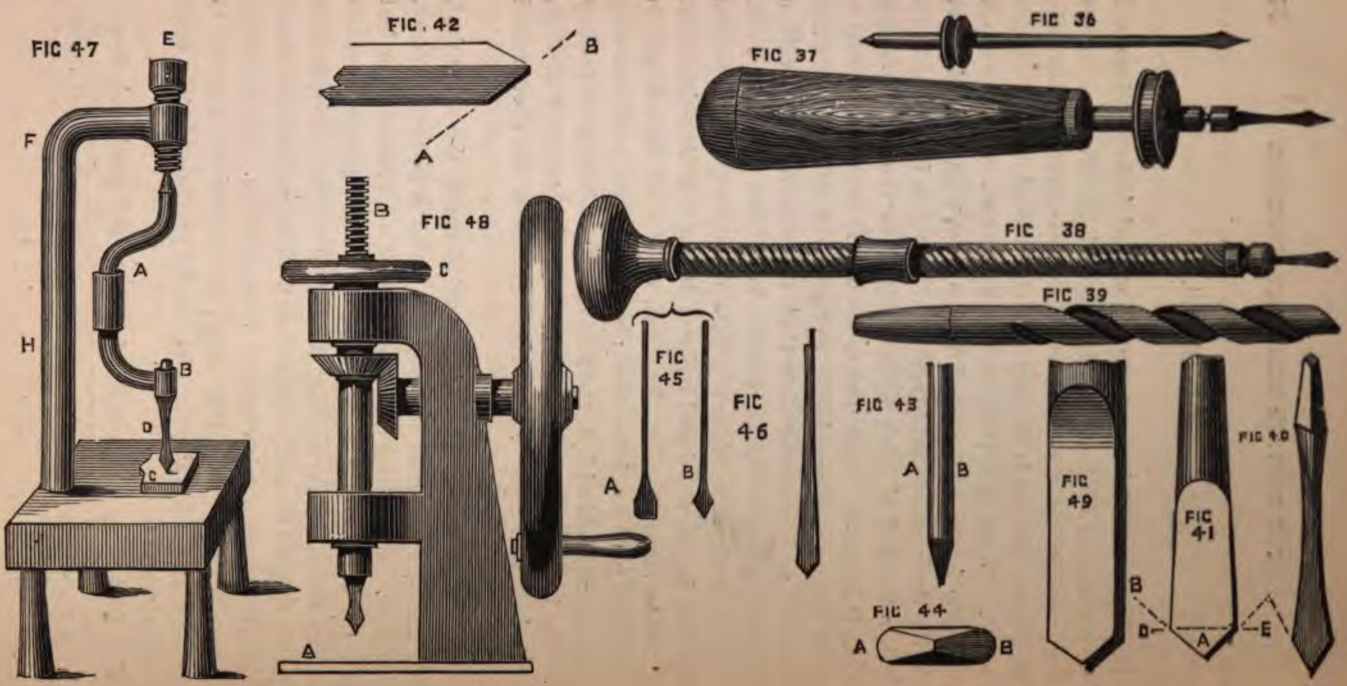


FIG 47
E
F
A
H
B
D
C
FIG. 42
B
A
FIG 48
B
C
A
FIG 37
FIG 36
FIG 38
FIG 39
FIG 45
A
B
FIG 46
FIG 43
A
B
FIG 44
A
B
FIG 49
FIG 41
B
D
A
E
FIG 40

essentially bad. The angle of the point is far too acute, and when it has been made to penetrate it does so too long before the rest of the drill can take up its place in the hole, and the tool will make a bad hole, not round or smooth, and probably the drill will stick fast and break.

Fig. 41 does not appear so sharp. It has a right-angled point, and this may be exceeded, but should never be less. The bevel, too, of these edges should be carefully considered. It may be observed that they are each a cutting tool for that metal on which it is intended that they should operate.

Fig. 42 represents half of a drill, the remainder being merely outlined to show its form. A B is the cutting edge, and if properly made, this might be held horizontally, and used as a turning tool, and if for iron the bevel would be ground at from 60° to 80° with the top plane; if for brass, 80° to 90°, but at the latter the tool would have to be tilted to bring it into cut, and this cannot be done with a drill, therefore it must be ground at a somewhat less angle, say 70° to 80°, always supposing the point B A C to form a right angle. The extreme end of a drill is a chisel edge formed by the meeting of the two oppositely-inclined planes composing its side edges. This should be reduced, so as to give more of a point to the drill, by grinding the flat sides rather more freely here than higher up, so that the section and plan may be as Figs. 43 and 44 The edges A B should be always rounded, indeed, the drill should be made of a round bar, which should retain its parallelism to the spot where the grinding of the two sides commences, and thence it should gradually enlarge to the line D E, Fig. 41, that it may work its way easily. A drill thus carefully made will bore a very good and even hole, and will not chatter as it penetrates, but a drill with an angle much less than 90°, and bevels less than 60°, with a broad chisel point, is sure to take a crooked course, and leave a hole which needs the application of a rimer to render it fit for any purpose, save as an example of bad work.

We have said that the drill should be made of round steel or wire, and it should also be round where it enters the socket of the drill stock or lathe chuck.

If this part is squared, as often done, it will be impossible to insure the centrality of the drill point, and if the shank is likewise squared, or has any angles, instead of being round, the chips or shavings will be caught and crushed, jambing the tool, and causing it to twist or break, or to run out of truth. Of course, in very small drills, as used by watchmakers, these directions cannot be so fully carried out, yet if the principle is grasped and applied, even these minute tools may be made equally scientifically. A small piece of steel wire, being taken in its soft annealed state, is flattened at one end with the hammer, which spreads it like A, Fig. 45. It is then filed up like B, and bevelled on opposite sides. The point thus made is too abrupt; the hammering should be extended farther up the shank, Fig. 46, which gives a form agreeing with that already explained. The top of the shank is notched, which part coming against a flat place in the stock prevents it from turning in the socket when in use. A watchmaker is pretty sure not to make the angle of the point less than 90°, because most of his work is on thin plates of brass, and if the point penetrates too much before the sides come into action, the hole will be spoilt, or the drill will break. A broach is, however, generally needed to follow the drill and perfect the hole, as this must be quite round and true.

The main drawback to drills of the above kind used horizontally, is the difficulty of supporting securely the piece of work upon which they are to act. The watchmaker can indeed hold the small pieces requiring to be drilled in one hand, placing the opposite end of the drill, Fig. 36, in a small hole in the side of his table vice, while with the other hand he works the bow; but when a piece of larger dimensions or of awkward shape is to be operated on, it becomes far more convenient to lay it down upon the bench and clamp it there, while the drill is used vertically, which is, of course, impossible with the ordinary lathe drills. The hand brace of the blacksmith A, Fig. 47, with pressure screw E, is altogether so imperfect that it is a wonder it retains a place even in the poorest workshop. The part F is often made as a movable arm, sliding upon the upright H, to give greater power of adjustment,

the work G being steadied where necessary by large nails driven round it into the bench which forms the bed of this primitive machine. The drill scarcely ever retains the perpendicular, yet, somehow or other by main force it is driven through the work sufficiently near the mark for many common purposes.

Such, indeed, is the prejudice of the ordinary mechanic for retaining the implements of his trade used by his predecessors, that it is exceedingly difficult to convince him of their generally utter worthlessness, and if they suffice to do the intended job of work he rests contented with "jobbery," of a truth, and pursues the beaten track with a perfect *nonchalance* and satisfaction.

It is to be hoped, nevertheless, that a better day is dawning, and that the influence of the present numerous mechanical and scientific journals will effect vast improvements even in the village workshop, especially as such improvements will be found upon trial not only to reduce labour and produce better work, but to save time, and consequently pay. For hand-drilling nothing can surpass No. 48, the bevel-wheel drill of Nasmyth, especially when the platform A is fitted with clamps to hold work of any accidental form. The actual drill socket which is depressed by the wheel C acting on the screw B, slides with a slot-and-pin movement through the sleeve which carries the second bevel wheel. Sometimes the platform itself is made to rise by a lever and pedal to work with the foot, or with a rack and pinion, actuated by a lever and adjustable weight. The cost of such a drilling machine is from £5, and the outlay will amply repay the amateur who really intends to do good and satisfactory work in metal. If, however, the crank brace is a necessity, let it be well made, so that the upper bearing point which comes against the pressure screw, may be in a right line with the drill, and above all have the latter well and scientifically formed. In Fig. 49 is shown a drill with a hollow scooped out to give a keen edge. In this way great sharpness is obtained, and the drill cuts cleanly and rapidly, but the edge must not be left too thin, or its strength will be unduly diminished. In boring cast iron the point of the drill is often done away with altogether, so as to present to the work a semicircular edge of two bevels. This

form of tool bores rapidly and well, but the hole must be commenced with a point drill.

There are some other forms of importance, as pin and re-centering drills, which we shall have occasion to notice hereafter. Drilling is indeed of such importance in a workshop that it is well worth careful study, especially as the amateur is very apt to fail in this kind of work from want of accurate knowledge no less than want of practice.

It is often better to bore a large hole by the aid of the pin drill, Fig. 50. The cutting edges *a b* are made on the principle of ordinary tools for metal, with a bevel therefore of 60° to 80°, but instead of the two edges meeting as before to form a point, the central part is turned in a lathe.

This forms merely the guide, and is inserted in a hole, previously drilled, of the same size as this pin or bit. Such hole is consequently enlarged at once by this tool to the size of itself, the metal curling off in shavings. Great care is requisite not to make the guide hole first drilled too large, as the pin should exactly fit it; it is also absolutely essential that the hole should be perpendicular, as this pin-drill will *follow* but not *correct* it. As this tool cannot cut away the entire hole first made, the latter forms a guide for the reapplication of the small drill, if it should be necessary to deepen the recess. If, however, the engineer's boring bit has been used, which will be presently described, and which leaves a level surface at the bottom of the hole, the centre of the latter can only be formed with the re-centering drill, Fig. 51, the lower part of which is cylindrical, and turned to fit the hole already made. The point is frequently made by inserting a very short drill in a hole in the boss so that it can be readily sharpened or repaired if broken.

To recapitulate the *essentials* of a good drill: It must always be made of a round, and not square, octagonal, or other shaped bar of steel, because the shavings and dust will more easily escape as the work proceeds. The drill should be parallel when flattened, or at most be *very* slightly larger downwards, not suddenly spread out by the hammer. The angle should be obtuse at which the

bevels meet to form a point, not less than 90°, and it may be even larger; and the angle of the two bevels themselves must likewise be large, because it is impossible to obtain a *sharp* edge by lessening this angle; the result will simply be that, after it has taken a couple of turns, there will be no edge at all left. If it is desired to obtain keenness, the tool must be grooved so that the edge is obtained by filing from above, Fig. 52, which shows the similarity

FIG. 50

FIG. 51

FIG. 52

FIG. 53

FIG. 54

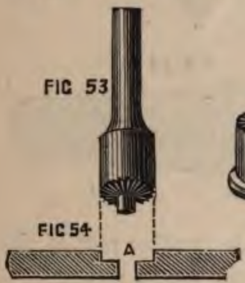
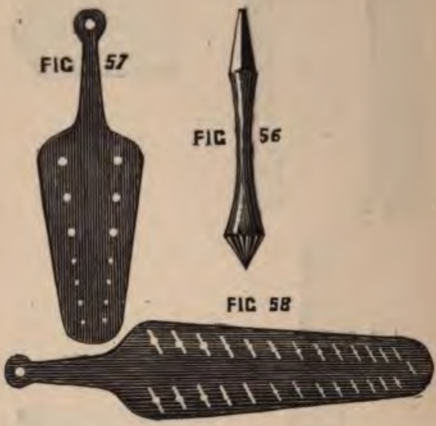


FIG. 55

of a drill thus ground with a turning tool for metal. Lastly, in making an ordinary (not grooved) drill, slightly bevel the *flat* sides also towards the chisel-shaped point, so as to reduce the thickness, and give more penetrative power. By following these directions a good tool will be obtained, which will do its work easily and well. Drilling in the lathe need not be entered upon here. There are, however, a pair of tools much used by gunsmiths, one of which is closely allied to the drill, which are worth

describing. It frequently happens (especially in making gun-locks) that the cylindrical head of a screw requires to be neatly countersunk, that it may be level with the plate through which it passes. To effect this the hole is enlarged with a peculiar countersink (Fig. 53), which combines the ordinary pin drill already described, and what is called the rose bit, a form of which (Fig. 56) is the ordinary countersink of the carpenter and smith, used for letting in the conical heads of wood screws. The tool in question is made like Fig. 53, and is used with either a drill stock, worked by a bow, or other available contrivance. In this way a neat recess



(A, Fig 54) is made in the plate or other part of the lock. The fellow tool (Fig. 55), acting on the same principle, cuts the shank of the screw blank, and levels the under side of the head already turned to fit the recess, and it drops so accurately into place as to be invisible when the plate and the screw head are polished together. It should be mentioned that the screw blank is turned nearly to the required size, and tapered a little to allow the end to enter the hole in the centre of the cutter, which is held in the vice when used. The head of the blank is nicked with the saw, and a screw-driver put in the ordinary brace, by which the blank is then screwed into the cutter by a few rapid turns. The shank

is thus certain to be cylindrical, and is ready to be tapped with a screw plate. The shanks of all screws thus made are, moreover, precisely of similar size. These are very useful tools for the amateur, and, indeed, the shank of such a blank may be even rounded with a file, and then run through the cutter, if a lathe is not at hand to turn it.

SCREWING.

To cut a thread on such a screw blank is an operation of such frequent occurrence that it will be well in this place to say a few words respecting it. There are three methods of effecting this. First, by means of a lathe, which is chiefly suited for screws of large dimensions, or in which the most perfect accuracy is required. Secondly, by the screw plate (Fig. 57), which will be familiar to most readers. Thirdly, by screw stock and dies, which is by far the best for general purposes.

The possibility of making good work with a screw plate depends principally upon the correctness with which this tool is made. Ordinarily it is a mere plate, of the form shown, drilled with rows of holes, which are then tapped The plate is afterwards hardened, and is ready for use. In this case there is no cutting action whatever ; the blank is turned or filed up, so as to enter with difficulty the appointed hole, and then by force screwed into it, whereby a thread is raised or *burred* up upon its surface. It requires no microscope in this case to reveal the defects of such a screw. The thread is of necessity rough, weak, and shallow, part of it probably even cracked, if the iron is not of good quality. Fig. 58 shows a plate in which, by cutting longitudinal or transverse notches into the main holes by the aid of a drill and small saw, two improvements result. First, there is a place for the escape of the shavings or dust produced ; and secondly, there are four partially cutting edges provided at the points where these saw cuts penetrate the central hole. If the tapped holes are in pairs, the one *slightly* larger than the other, but with a similar

thread, very fair screws may be thus made; but generally speaking this accuracy is not attended to in making the plates, and the pairs of holes are precisely similar. The taps (in almost all cases) which are sold with screw plates, are simply abominable, shapeless, and clumsy to the last degree. Some of the better-finished plates used by clock and watchmakers who work almost exclusively with this kind of screwing apparatus, are better finished; but, after all, the screw plate is a poor tool, only fit for making screws of small size, on the threads of which no great strain is likely to come. We do not recommend them, therefore, to the notice of amateurs, except for screws below $\frac{1}{8}$in. in diameter, and even then we advise that they be carefully selected at the best tool shop available, even at a somewhat higher price.

To make the best work possible with this tool, it is necessary to be very careful to fit the blank accurately. It must not taper in the least, except at the extreme end, to permit it to enter the hole in the plate. If it fits too tightly it will be twisted and probably broken off short in the hole; if too slack, the thread will be defective—too shallow for use. The exact size would seem to depend upon whether half the thread can be considered as cut into the metal and half burred up, in which case the blank would be of such size as to fill the hole in the plate and extend half into the thread besides, which is practically about what is required.

For many light works, as iron and brass wire, binding screws, and such other small bolts as the plate is commonly used for, this is at any rate sufficiently near the mark to serve as a general rule.

It is of great importance when screwing either with the plate or stock and dies that the pin should be passed perpendicularly through the tool, else the thread will take a slanting direction, and when the bolt is screwed in its place the head will not fall accurately into its place. This error, however, is less likely to happen with the screw stock, because the dies are thicker than the plate, and, thus embracing more of the pin, tend to place *themselves* accurately upon it. There are now several patterns of die stock, of which Whitworth's is the best, having three instead of two

dies, one acting as a guide, while the others cut the thread. The two movable ones are simultaneously advanced to the work as the screwing proceeds, and the latter is effected with great facility and with the least possible strain upon the bolt. Unfortunately, however, the cost of these screw stocks is necessarily far heavier than that of the more common stocks, which merely carry a pair of dies adjustable by a set screw.

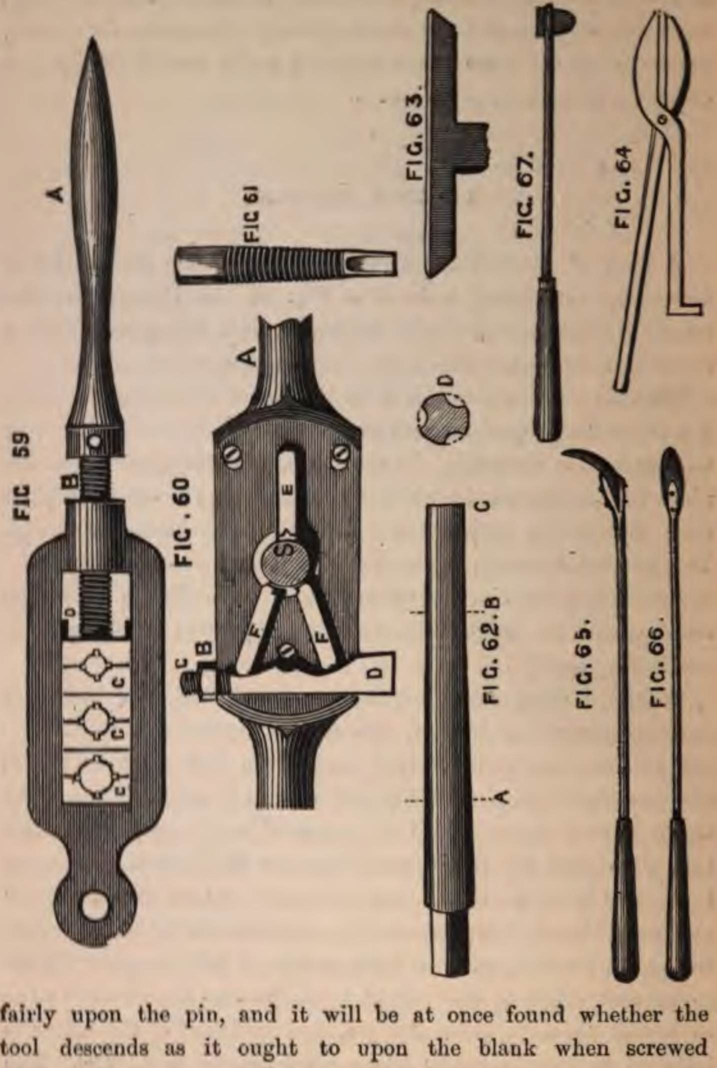
DIE STOCK AND TAPS.

A form of diestock for light work containing three pairs of dies in the same frame, is shown in Fig. 59. In this pattern the handle is continued through the frame, and, being made into a screw at B, forms the means for compressing the dies.

The only drawback to this is the likelihood of bending the screw B; it is never, therefore, used except for small bolts not exceeding half an inch in diameter. In the above, and other patterns of the same for heavy work, in which the compressing screw is distinct from the handles, only two dies are used for cutting the screws. The notches, however, in the dies give several cutting edges; and as the better form of screw stock, with three dies, is costly, the above forms the most usual screwing apparatus of the general mechanic.

To use a screw stock requires no great skill, yet there are defective screws made by it. Sometimes, instead of a thread, the tool cuts merely a series of rings parallel to each other, and it is also possible to cut a double thread instead of a single one. Let the bolt be truly turned to the intended size corresponding with that marked on the dies themselves, for in the present case metal is removed to form a thread, the recesses are cut out instead of the projecting thread being raised. The screw blank being fixed with its head in the vice, with the interposition of lead or wood clamps to prevent injury to the turned head, the dies are loosened so as to permit them to grasp the pin, and sufficient of the latter is included between them to give a good bearing to the tool. The

dies being tightened, but not more so, at first, than is necessary to mark rather than cut the thread, a turn or two is taken with the screw stock, which may be slightly shaken to settle its position



fairly upon the pin, and it will be at once found whether the tool descends as it ought to upon the blank when screwed downwards.

If not, let the dies be loosened and reclosed a little lower down, and a fresh attempt made; and if this is successful it will be well at once to tighten the dies a little more so as to make them cut. Oil must be freely used as the work proceeds, and it is a good plan to work the stock to and fro a little as it descends; but the dies must not be tightened except when the top of the pin is reached, and the deepening of the thread commenced.

If this is not attended to the thread will be more cut in one place than another, and the diameter will no longer be uniform from end to end. The work must be continued until the thread is seen to be sharp at the edge and well finished. The dies will not generally be quite close when this is the case.

Fig. 60 is an illustration of the stock of Whitworth and Co., with three dies, as figured and described in Holtzapffel's work on mechanical manipulation. E is a fixed die which is not intended to cut, but to form a guide, its threads immediately falling into those made by the movable cutting dies FF.

These, it will be seen, are in a measure hooked, and in such a way that one will cut as the tool is turned round upon the blank from left to right, or descending, and the other will take up the cutting as the stock revolves in an opposite direction. The cutting is thus rapidly proceeded with. D is a double wedge of hardened steel, acting simultaneously on the pair of dies when the octagonal nut B is turned on the screw C, which forms part of the wedge D.

The working of the dies and wedge is concealed by the upper plate of the screw stock, which can be immediately removed by loosening the three screws in its face, and sliding the plate till their heads fall into the holes adjacent to them, these being the shape of a keyhole. Nothing can exceed the ease and accuracy with which these patent die stocks work, the rubbing action being merely sufficient to compress the threads slightly, and thus solidify them, while they are actually formed by the clean cutting action of the movable dies acting like a pair of turning tools.

Fig. 61 represents a common tap of the old taper form, the thread removed in part by the formation of four flat sides. The

cutting edges, therefore, such as they are, are confined to the four angles, and the tapping by such a tool is not only unsatisfactory but in addition uncertain; for at the first entry of this tap its action is frequently that of a rimer, and instead of cutting an inside thread it simply enlarges the hole. There is in the above no guide principle to insure its proper entry, and consequently it is a mere question of chance whether the resulting work is good or bad. Compare this with Fig. 62. In this, which likewise represents a taper tap of proper form (the thread being purposely omitted), attention is given to all the several requirements of a good and practically efficient tool.

The tap is first turned as a cylinder, after which it is carefully threaded. It is then returned to the lathe, and the threads from B to C are cut away, but only just so.

This part, therefore, is of the exact diameter of the tap at the bottom of the threads, and the nut to be screwed is bored so as just to admit this, which at once insures the perpendicularity of the tool. From B to A the tap is gradually tapered, so that its diameter increases until at the point A the thread is quite perfect and sharp.

Beyond A the tap remains cylindrical, and the square part left for the tap wrench is purposely made smaller than the rest, that it may fall through the nut when its work is done, instead of having to be withdrawn by carefully turning it backward, a process sometimes resulting in obliteration of the newly-made thread.

From A to the smaller end the tap is fluted, as seen in section D. Three flutes appear best suited to the end in view, which is the production of cutting edges; and these flutes are not always made as radial grooves, but in such a manner as to cut more keenly on one side, the other being purposely eased off. Radial grooves, nevertheless, answer very fairly, and are in very general use.

With such a tool as the above die stock, with a few pairs or sets of dies of sizes most likely to suit the purpose of the amateur, it is hardly possible to make bad work; but it is necessary to be careful as to the exact size of bolt and nut, so that the latter, when

tapped by turning the tap in one direction until it drops through, may exactly fit the bolt for which it is intended, the latter being gauged carefully to the size marked on the dies, according to directions already given.

The taper tap alone is sufficient for thoroughfare holes ; but when these do not go through the work, but are more or less shallow, three or four taps are required, the last alone being cylindrical and of the exact diameter of the hole to be threaded.

WORKING IN SHEET METAL.

The subject of metal working which forms so large a portion of amateur mechanics' work, would not be complete without a brief notice of brazing and soldering, and working upon tin, copper, or brass plate.

The use of the former metal is, perhaps, the most general in matters domestic, and the use of the soldering-iron is an accomplishment of real service in every household. Few tools are needed for this kind of work—a straight, semi-sharp stake of iron, (Fig. 63), which can be mounted in the vice, and serves to turn down the edges of the tin where required in conjunction with the hammer, or, more commonly, boxwood mallet, with one flat and one round face; a pair of small shears (Fig. 64), one leg of which can be fixed in the vice, if the metal is too thick to be easily cut by hand alone. These, with the addition of an ordinary pair of pliers and the soldering-iron or copper-bit, suffice by themselves for most of the ordinary work that falls to the lot of the amateur.

The solder used by the tinman is made by melting together two parts of pure tin and one part of lead. This may be easily effected in an iron ladle, an instrument of very great use in the workshop of the amateur. A flux will have to be used, resin being the most common, and generally answering the purpose. There are, however, one or two others which deserve attention, and will be noticed

in their proper place, being more useful for copper, zinc, or brass than for tin.

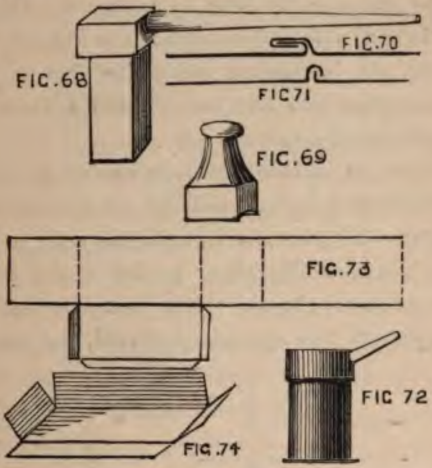
The soldering-iron (Fig 65) is a very handy little tool. The bit is small and curved, so that it is not top-heavy, as the more common irons (Figs 66 and 67) are, in which the copper-bit enclosed in the split end of the iron shank is generally heavy, making the tool awkward to use. But the first is nevertheless only fit for light work, because the small bit will not long retain sufficient heat to melt the solder; its copper part may be 2½in. long and about ⅜in. to ½in. square. This little tool the amateur will find nicely suited to his work. It is used by makers of tin lanterns, and such small articles.

Whichever pattern is preferred, the extreme end of the copper will require tinning, as otherwise it will not pick up the solder which it melts, nor carry it along the seam in a neat and workmanlike manner. The best way to effect this is to make a hole of an oval form in the surface of a brick, deeper at the farther than at the nearer end; a depth of half an inch, or a little more, will be sufficient. Having filed the end of the copper bright, with a smooth bevel on one or both sides, so as to form a conveniently shaped edge for the purpose required, heat it almost to redness; wipe it clean, and having placed a little piece of solder or tin, with some resin, in the hole of the brick, apply the copper-bit to the same, and rub it about well in this hole; it will presently become brightly tinned and fit for use.

Fig. 68 is a beak iron for forming tubes. Fig. 69 is a seamer or seam-set, a hollow punch for closing up joints neatly; it also serves to begin bending a strip of tin to form a small tube. The tin being driven into the groove in its surface by the flat pane of the hammer, it may be finished by the application of a similar punch upon its upper surface, or over a beak iron. There are a few other simple tools used by the sheet metal worker, which will be named and illustrated when necessary.

In joining sheets of tin the ordinary seam is made like Fig. 70. The edge of each sheet is turned over upon the hatchet stake, the two are hooked together and beaten down, after which a little

solder is neatly run down on both sides. If one side, however, of the tin is to remain flat, the seam must be made as Fig. 71. The edge of each is to be turned up, but the width of this turned-up part is to be greater in one than in the other; the wider is to be again bent over the narrow one, and both hammered down, the seam-set being used to perfect the rounding of the joint on the raised side. The solder may be then run down on the inside, making a very neat job. It is thus large tin saucepans, requiring more than one sheet, are made, with other similar works.



Now, in this, the neatness of the soldering will chiefly try the workman; a regular tinman never goes over a seam twice, and he spreads a thin coat of solder so neatly and evenly that it is scarcely visible when done.

One requisite is a well-tinned soldering iron; another, to have this iron very hot, but not *red* hot, or the tinning will burn off, and the tool will require to be filed up again and retinned. A third requisite is a good flux. Resin is extensively used by the trade, and if the tin is clean and bright this substance can hardly be excelled.

There are, however, other preparations used when difficulty occurs, of which, perhaps, Baker's soldering fluid is the best. This

will answer for tin, brass, or zinc, the latter metal being very difficult to manage with resin alone. If the above fluid is not at hand let some pieces of zinc be dissolved in hydrochloric acid (spirit of salt), and the liquid thus formed be used.

The main drawback to fluids is the tendency they have to cool the iron; and some of them have a further drawback from their effect in eating the copper itself, destroying it and, of course, its coating of tin also.

Resin makes a terrible mess of the fingers, if it is taken up in pinches, as not unfrequently done by amateurs. The neatest plan is to have a tin can, with a short spout, like Fig. 72, by which the powdered resin can be shaken along the line requiring to be soldered in a regular and tidy manner, and tidiness is not to be despised in mechanical manipulation.

Working in tin is in many respects analogous to modelling in cardboard, the pieces being planned and cut on similar principles.

In making an oblong box, for instance, the sides and bottom may be cut in one piece, as Fig. 73, or (which would probably be the more economical mode) the sides may be cut in one strip and the bottom cut separately; or again, if preferred, the plan Fig. 74 may

FIG 75

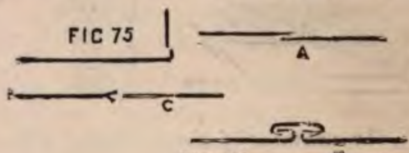


FIG. 76

be adopted; but in the latter case, if the bottom is intended to project a little all round, for the sake of giving a more finished appearance, a double fold, like Fig. 75, must be made in the sides, and hammered closely down, and to keep it thus folded it may be necessary to run a thin layer of solder very neatly round on the inside. Other joints used with (and some without) solder are represented in A B C, Fig. 76; the first, however, is scarcely to be called a joint, as the pieces merely lie over each other, and union is effected solely by means of the solder applied on both sides.

It is unnecessary here to lay down rules for cutting out pieces

of complicated form. Boxes of five, six, or more sides are readily designed and laid out in plan by the aid of rule and compass, and any pattern can first be made in paper by way of experiment.

In most cases there should be lapping edges left, as in the plan, Fig. 73, which will form stronger and better work than when the edges are made to meet only; the latter, however, is the rule in hard-soldering or brazing, which will be treated of presently.

Sheet brass is cut and worked in the same way as tin, and the same solder and flux may be used except for very fine neat work, which is united with laminated silver, moistened with borax and water. This, however, is an example of hard-soldering, and cannot be effected by the soldering iron, as the heat thus obtained is insufficient. A very neat union of two pieces of brass may be made by using tinfoil as the solder. Let the surfaces be made quite clean and bright, and moistened with sal ammoniac and water, or sprinkled with resin, or, if preferred, wetted with any of the soldering fluids already mentioned.

Insert a piece of tinfoil clean and free from grease between the pieces, and either pinch the whole together with red-hot blacksmith's tongs, or, first securing their respective positions with iron wire or other methods, heat them over a fire until the tinfoil melts. This is a very convenient and efficient mode, applicable in many cases, especially in the construction of small models of engines and similar neat work in brass. It must be always borne in mind that thick pieces of metal cannot be soldered with the soldering iron alone, as it is essential that both the parts to be united shall be brought to a heat equal to that of melting solder, but when for instance a small block of brass is required to be thus joined to a thin plate, the former may be first heated in the fire, and then the process can be carried on with the iron, which may suffice to heat the thinner piece of metal. If the iron is well tinned, and is drawn slowly along the joint with a sufficient supply of solder, little difficulty is likely to be experienced in this work. The tinned soldering iron (or copper bit) will pick up the solder and carry it evenly along the joint; or, the solder being held in the left hand and the iron in the right, drops of the former may be melted

off the lump or strip (the latter is the most convenient), and allowed to fall at intervals upon the part to be joined, and the heated iron being then applied will spread these into one long thin layer.

It is a good plan with brass, and necessary with iron, to tin the parts separately, first of all, that are to be united, so as to secure the *taking* of the solder. Sal ammoniac is the salt to be used in this, or Baker's fluid, the metal having been first cleaned by the file and sandpaper. Iron wire will frequently take the tinning satisfactorily with the aid of resin only, but sal ammoniac is to be used in tinning cast iron.

THE BLOWPIPE.

In this little instrument we have at once the means of producing a heat *intense*, convenient, and free from smoke and dirt, and for delicate work nothing can equal it. True, it is a little difficult to use at first, as it requires practice to keep up a steady blast for any considerable time. The secret is to blow only with the muscles of the cheeks, which are to be full and distended as those of any Scotch piper. These muscles keep up the blast while by a momentary effort of the lungs the supply of wind is renewed. It is not difficult after a little practice to get the chest and facial muscles thus to act independently of each other, and, the knack once acquired, no attention is afterwards given to it, as cheeks and lungs and lips will do their respective work, each at the right moment, without any effort on the part of the operator.

Of blowpipes Figs. 79 and 80 are the ordinary forms, the latter having a reservoir to catch any water or condensed vapour from the breath, but in using these both hands are not at liberty. The best arrangement is shown in Fig 81, a remarkably handy little blowpipe, which can be directed in any position through the flame of the lamp. It is made by J. J. Griffin, 22, Garrick-street, Covent-garden, who manufactures all kinds of blowpipes for gas and spirit-lamps, besides divers other pieces of apparatus handy for the

amateur mechanic. This blowpipe is 10s. 6d.; another at 25s. is made with indiarubber ball to press with the foot, to produce a blast, and a second ball as regulator, the whole handy for any such purpose as soldering or small brazing. Blowpipes with fixed stands can also be had with a flexible tube to the mouthpiece, which gives

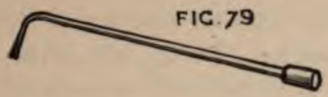


FIG. 79

the operator greater freedom of position. Fig. 82 is one of these. Either of the above will suffice for ordinary soldering; but if hard solder is to be used the object to be brazed must be small, or the mass of metal will carry off the heat so fast that the spelter will not be melted or the metal raised to the necessary temperature.

FIG. 80

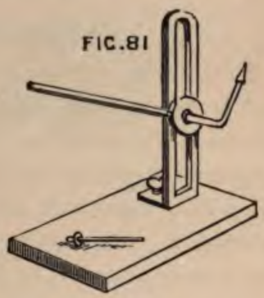


FIG. 81

FIG. 82

Either of the mixtures given here, for which I am indebted to Mr. Griffin, is superior to ordinary spirit or oil for blowpipe lamps:— 1. Mix alcohol of 85 per cent., six volumes; spirits of turpentine, one volume, with a few drops of ether. 2. Mix wood spirits, four volumes, with turpentine, one volume. Both must be clear, with-

out excess of turpentine. *With these mixtures a blowpipe has power to melt* 30 *or* 40 *grains of copper, or* 300 *grains of silver.*

Small work is commonly supported upon a piece of flat charcoal. A more convenient support, however, in one respect—namely, its incombustible nature—is pumice-stone, a lump of which can have one side flattened or rasped to any desired shape to suit the work. Having already recommended neatness, we may add that a box should be set apart for soldering, with divisions to contain the powdered fluxes, the spelters and solders, small pliers and other apparatus, with a bottle of soldering fluid to be spread either with a flattened wire or feather. Neat apparatus conduces to neat work, and neat work is specially essential in the construction of small models of machinery, or soldering fine work of any kind, jewellery, and so forth.

BRAZING.

This, which is the same as hard-soldering, is of very extensive application in the mechanical arts. The substance used as solder is spelter, a compound of copper and zinc in equal parts, of rather lower fusibility than the former metal alone, and therefore applicable for soldering it. The respective melting-points are nevertheless sufficiently near together to necessitate great care in the management of the operation. Iron not being similarly fusible, is often brazed with brass without any addition of zinc. A blacksmith, for instance, will generally mend a broken key as follows, and this will be a sufficient example to guide the amateur in any similar case. The broken pieces are to be first dovetailed, or scarfed, or otherwise so fitted that they can be held in their places in close contact by a twist or two of iron wire. The metal should also be cleaned with a file. Brass binding wire is now to be wrapped round about the place of intended junction, so as to make a knob, or small mass of metal. The actual quantity of wire required depends upon the size of the fracture; but it must be remembered that when the wire melts it will occupy far less space than when thus roughly

wound. The whole is now plastered with borax made into a paste with water, or the dry powder may be used, and the metal is then held over a clear forge fire, but should hardly touch the fuel. Presently the borax will swell up considerably, unless (which is a good plan) it has been previously fused, so as to drive off the water naturally present in it. When this swelling of the salt has subsided it will run like glass in amongst the wire coils and upon their surface, and shortly after the wire will itself fuse with the appearance of a blue flame, which last announces the vaporising of the zinc in the brass. The operation is then completed, and the whole being removed from the fire, needs only to be cleaned off with file and emery; and if the work has succeeded as it ought, there will only be visible a thin line of yellow metal in the joint, and the latter will be almost as strong as the rest of the piece.

FIG. 83

Let it be desired to braze together the parts of a small boiler of copper. This, if of the simplest form, is merely a short tube of a diameter nearly equal to its length. Cut a strip of metal sufficient for the purpose, filing the edges true, so that they will meet accurately when the piece is rolled up to form the cylinder. Tie with loops of fine iron binding wire, as in Fig. 83, having previously cleaned the parts that will be near together,—say, a quarter of an inch wide of each edge. Along this seam on the inner brightened part lay a line of thick borax and water about the consistency of cream, by the aid of a feather or flattened wire, and upon it a line of granulated spelter. Holding the tube in a pair of light tongs over the forge fire, let the borax quietly fuse until it lays hold of the grains of spelter, when the tube should be turned over and heated on the other side* to equalise the temperature; then turn

* It will be better to heat the opposite side first.

it over and gently urge the fire until on looking *into* and *through* the tube the blue flame is seen—a proof, as before stated, that the solder has flushed along the joint; gently tapping the tube will more surely establish the spelter in the seam, but the whole must be removed *at once, or the tube will melt.* The latter may now be drawn, filed, turned, or hammered as if made of one continuous piece of copper. The ends of these small boilers are usually *cast* brass, but it is just as well, if the tubular part is of copper, to make ends of the same material; and, be it remembered, copper is selected because under pressure exceeding the tenacity of its constituent particles it will not burst and fly about dangerously, but will rip and tear like paper. The ends, therefore, being supposed to be merely circular pieces cut out of a sheet of metal, may

FIG.84

FIG.86

FIG.87

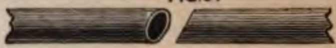


FIG.88

be fixed as follows, the joint to be described being very strong. The sau e kind of joint may of course be used instead of the butt joint (before noticed). Both are, however, given for the clearer understanding of the method of brazing.

The edges of the tube at each end are to be snipped with oppositely inclined cuts, as shown in Fig. 84. Every alternate piece of metal is to be bent inwards, and upon these the circular piece is to be laid. A cylinder of wood or metal is then inserted in the tube as a stake or mandrel, and the alternate slips left standing are to be hammered closely down upon the bottom piece Borax and spelter are then to be laid round inside the tube, and the heating is to proceed as before, after which the joint can be hammered and filed, or turned quite level and smooth.

To fix in the other end a somewhat different mode must be practised, as it cannot possibly be brazed from within. The easiest

method is to make quite level the end of the tube, cut the circular piece rather larger, so that it will project a quarter of an inch all round, and secure it with wire, as in Fig. 83. Round this projecting ledge of the bottom (or top, as the case may be) the borax and spelter are to be laid, and the whole held over the fire as before When the spelter has run, the extraneous part can be cut off in the lathe, or with the file. It is possible to fix the second circular piece within the tube, as in the first case, by taking care to fit it tightly, and to leave it a little below (or above the extreme end, according to the position of the tube); but in this mode only a little can be brazed at one time, as the tube must be laid upon its side and rolled over as the work proceeds; whereas, if done as described, the large circular end being downwards next the fire, the spelter can be made to flush all round it at once. In point of fact, the second end of a boiler for a model does not need *brazing*, as, if made the *top*, and therefore out of reach of the flame or fire by which the water is to be evaporated, ordinary tinman's solder may be safely used, and more choice can be made of the particular form of seam that may appear appropriate. It matters not what article is to be hard soldered or brazed, the process is always the same, modified only by the size and shape of the material. The art is of too great value not to be well worth acquiring, and a steady hand and good eye are the chief requisites. After a tube of brass or copper is thus soldered it is usually cleaned by being dipped or pickled in a mixture of sulphuric acid and water. This cleans the surface, which may then be polished with rotten-stone and oil, and afterwards lacquered, a receipt for which will be given at the end of this series. If the whole of such a boiler is of copper, the sockets will have to be soldered into the top, into which should *screw* the various fittings. It is, however, better to make the top of a plate of cast brass, which can be turned in the lathe and drilled and tapped as required, thus avoiding the necessity of soldering. If the amateur is likely to engage extensively in model making or other work requiring brazing, it will become absolutely necessary for him to purchase a small forge (a *portable* one is convenient), or to arrange a blowpipe table of some kind which may

be used with a small blacklead furnace made to stand on the table and supplied with coke and charcoal fuel. The same blowpipe table will answer for a direct blast through the lamp for fine work and for glassblowing, and is, upon the whole, one of the most generally useful contrivances possible for the production of heat. In making chucks and lathe apparatus, brazing and soldering are very largely employed; the latter sometimes as a temporary expedient only, to hold together parts of apparatus which can then be drilled, tapped, and fitted with screws without any chance of shifting their position, and after being thus fitted the application of heat will enable them to be separated, and the solder will wipe off quite clean.

It is not often that working in lead, pewter, gold, or silver comes into the list of amateur workshop operations, which are generally confined to manipulations in wood, iron, or steel, and brass or gun metal. It is nevertheless well to know something of the method of soldering these; especially as in the attempt to repair such articles as pewter and Britannia-metal coffee-pots and the *cheap* electro-plated ones, another hole may result from the application of the solder to repair that which first existed, the metal itself being of easier fusibility than tinman's solder. Lead may be soldered with the common copper-bit used for tin, or by pouring from a ladle melted solder upon the parts to be united. If it is desired, for example, to join together two pieces of pipe, these may be filed to meet in a butt joint, Fig. 86, mitred or scarfed (87); or the boxwood plug, Fig. 89, may be used to open one pipe, Fig. 88, and the other scraped to a conical form and inserted into it, the two may then be soldered and a strong joint made. The plumber invariably limits the extent to which the solder shall reach upon the work by painting that part which is not to be covered by it with soil, a mixture of lampblack and size (or thin glue). The part on which the solder is desired to take effect is then scraped clean and bright with a handy little tool called a shave hook, represented in Fig. 90. It is merely a small triangular piece of steel with three sharp edges, attached to a central wire stem terminating in a handle. The inside of the triangle

is flat, the outside somewhat rounded and bevelled off to form the edges. The parts to be joined being in position and greased with tallow as a flux, the plumber takes in his hands a thick pad of ticking, greased; and holding it under and close to the pipe, an assistant gently pours upon the latter some melted solder, which is pressed into shape upon the pipe by means of the pad. This is further shaped and improved by the plumber's soldering iron, Fig. 91, which is wholly of iron and not tinned. The joint is sometimes made smooth, sometimes striped, but nearly always left in shape like an egg. In fine work, such as soldering together small strips of lead, the ordinary tinman's copper-bit is used, with tallow or resin. The plan of soiling always gives a neat appearance to works in lead, as the solder ends in a clean bright line, while the lead remains of its ordinary bluish, dull grey colour. The hook at the end of the plumber's iron is merely for the

FIG. 91

FIG. 90

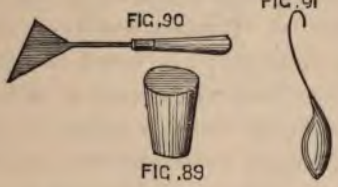


FIG. 89

purpose of hanging it up; and when the usual portable stove is used for outdoor work, three or four such irons are commonly seen hanging to the rail of it, ready for use. Pewter, which is a compound metal made of tin and lead, or tin and copper—the last being the best—tin being in either case in greater proportion than the additional metal, may be soldered, if not very fusible, with tinman's solder; but as this substance is variously compounded, and is sometimes from excess of lead melted by the heat of such solder, it is safer to add bismuth to the latter to increase its fusibility. Two parts of tin, one of lead, and one of bismuth, is a solder very generally used, the copper-bit being also kept at a lower temperature than when used for tin, or rather tin plate, which is thin sheet iron coated with that metal. The flux used is

Gallipoli oil. This metal (pewter) is not unfrequently used to form collars for lathe mandrels, for which purpose, if of good quality, it answers fairly. The mandrel being placed in position in the poppet-head, and the two placed on end in a bed of sand, the metal is melted in an iron ladle and poured in round it. When cold it is smoothed off flush and even, and if the mandrel has first been slightly oiled, it will turn round with great ease, and there is a peculiar greasiness in the pewter which gives a p'easant smoothness to the running of the lathe. This will last a long time, and is easily renewed. The writer knows of a lathe in constant use by a gasfitter thus made with collars of pewter, and it is found to stand work admirably. There are many similar cases in the mechanical arts where collars are required, which may be thus arranged as a matter of convenience, although it cannot be pretended that for permanent work pewter is preferable to steel, or even gunmetal well bored and fitted. The lathe alluded to here was fitted with collars, made by melting an old teapot, which may possibly have been of Britannia-metal — a compound of tin, antimony, brass, and copper; this would be harder than ordinary pewter. The maker, however, believed it to have been made of pewter, and the latter will certainly answer the purpose admirably. The addition of antimony would have the advantage of preventing the metal from shrinking so much in cooling, and thus making the collars too slack, as antimony has the peculiar property of expanding when cooling after having been melted—it also gives to alloys a greater degree of hardness.

Articles of gold and silver are generally soldered with the blowpipe, and, being chiefly found in watches, jewellery, and similar manufactures, need not be treated of here, except for the purpose of mentioning that gold is generally soldered with silver, drawn into thin flattened wire, or both soldered with pure tin, with Venice turpentine as the flux. Tinfoil, as wrapped round tea and druggists' nostrums, is very handy for such work as brooches, pins, and small articles in general. The annexed table will be found convenient, as showing at a glance the solders and fluxes for the metals likely to be used in the workshop :—

SOLDERS AND FLUXES.

Metal to be soldered.	Solders used.	Mode of applying Heat.	Fluxes.	Remarks.
Tin	Two parts tin, one lead.	Copper-bit.	Resin.	Fuses at 340° Fah.
Lead	Two parts tin, and with more lead.	Melted in a ladle, and with solid iron, but not tinned.	Tallow.	Soil with size and lampblack where the solder is not to adhere; scrape where it is.
Brass	As tin.	Copper-bit, or blowpipe.	Resin or sal ammoniac.	Often soldered with tinfoil.
Do.	Spelter or silver.	Blowpipe or fire with blast (hard-soldering or brazing).	Borax.	Copper and brass are soldered with soft or tin solder, or brazed with spelter.
Copper ..	As brass.	Copper-bit with soft-solder or as above.	Do.	
Iron	As brass in each case.	As brass.	Resin or sal ammoniac.	If soldered, should be first tinned; it is usually brazed.
Zinc	As tin.	As tin.	Resin, muriate of zinc, Baker's fluid.	Difficult to solder neatly.
Pewter ...	2 tin, 1 lead, 1 bismuth.	Copper-bit or blowpipe.	Galipoli oil.	The harder qualities can be soldered as tin.
Britannia Metal ...	As tin.	As tin or blowpipe.	Resin.	
Gold	Gold, silver, and copper, in various proportions.	Blowpipe.	Venice turpentine.	The solders vary according to the fineness of the gold and its consequently degree of fusibility.
Silver	Two fine silver, one brass wire	Do.	Do.	

It is scarcely worth while to treat of the use of rivets, by which pieces of sheet metal are so commonly united. They are made of various metals, according to the use for which they are designed. Sometimes, as in boat building, in which copper rivets are used, a washer is slipped over the end after it has been placed in position, and the second head is formed by light blows of a hammer upon the cold metal. In other cases, as boiler making, the rivet is used red or white hot without the addition of a washer, one workman holding a sledge-hammer against the head, while a second, with a riveting hammer, spreads and forms the end. In this case, as the metal contracts in cooling, the joint is drawn very close. No heavy work of this class is likely to be undertaken by the amateur, by whom copper rivets, as being most easy to manage, will be used. If these are used with copper, or tin, or brass, and the rivet hole is required to be steam or water tight, they are easily coated with a little solder or tin.

Lacquering Brass.—However well-finished brasswork may be, it soon becomes tarnished by exposure. As a protection, and to add to the finish of the work, it is usually coated with a varnish of lacker, or lacquer. First, it must, if flat or without mouldings, be polished by emery of different degrees of fineness, and further finished by the application of rotten-stone and oil. The latter having in turn been cleaned off, dry rotten-stone should be used with a clean wash-leather. The article should then be placed upon a stove until almost too hot to be handled, when the lacquer is to be applied with a small brush, the best being a camel's hair paintbrush. The lacquer is thin and flows readily, but dries quickly. It should therefore be laid on by straight strokes of the brush given evenly and carefully, but with moderate speed, and the brush must be kept moderately full by being constantly replenished as it becomes empty. A little knack is required to lay an even coat, which, however, any one who can lay on a flat wash in water-colour painting will find no difficulty in effecting even over an extensive surface. It must be remembered that any, even the slightest, greasiness will be fatal to the application of the lacquer, and after the final buffing with dry rotten-stone the fingers even

should be carefully kept from the polished surface. In the end of this series one or two recipes will be given for making lacquer; but the amateur would generally save much trouble, and be more likely to insure success, by purchasing it ready-made. It is sold of various tints and depths of colour by Holtzapffel and others. Turned brasswork is of course treated similarly, but lacquered while in the lathe. The heat is obtained by friction in polishing, which, if the rubber is vigorously used, is quite sufficient for the purpose, but the lacquer will dry more slowly. Cast works in brass the amateur must not expect to finish up with alternations of brilliantly-burnished and rough parts, as done in Birmingham. This requires much practice, and there are secrets of the trade not accessible to outsiders. Nevertheless, the same style may be managed in a quiet way; and it is a very neat mode of finishing models in which, from the form of the castings, parts cannot, perhaps, be turned or filed to a smooth surface, but have to be left rough as they came from the sand of the founder. The following is the process:—The casting is first of all cleaned by being placed in a bath of nitric acid one part, water three parts, in which solution it is to remain an hour or two. It is then to be removed, washed in water, and well scoured with a hard brush with the aid of sand and water. It is now to be carefully washed again, and before the atmosphere has time to act upon it, it is to be placed in a basin of clear water till the dipping acid is ready. For this, either pure undiluted nitrous acid is used, or equal parts of nitric and hydrochloric acid, forming *aqua regia*, which is a solvent for pure gold and platinum. The casting is to be taken out of the water and dipped just a second or two only in the above solution, and immediately withdrawn, washed in two or three waters, and dried by being placed in hot sawdust of beech or boxwood. It must then be at once varnished or lacquered, to preserve the surface from tarnishing. If any part or parts are to be left quite bright they must be quickly burnished with a steel burnisher before the lacquer is applied. There are, as above stated, lacquers of different colours, and in addition various other varnishes sold under the name of japan. The true japan is of great beauty, being a splendidly

brilliant and durable black; but as it requires the aid of a special stove, it is not likely to be used by the amateur. Brunswick black, on the other hand, is simply a varnish of the consistence of paint and similarly used. It is a fair substitute for the first, if varnished after it is dry. Another brownish black varnish, also called japan, is that used generally for tin vessels for household use. It is very bright and clear looking. Recipes for the above will be given.

Bronzing is another method of finishing cast-iron or brass articles, giving them a greenish and golden appearance of great beauty. This is often effected by simply painting with the above colours, and giving a final coat of some clear varnish. The real bronze is produced by the chemical action of an acid on the metal itself. After this has ceased the article is washed, dried, and rubbed with black lead; then lacquered with greenish transparent varnish.

MANIPULATION OF WOOD.

This must of necessity be treated of briefly in the present series, not that it requires less care and skill, but because, with a few exceptions, amateur mechanics do not practise carpentry on anything like an extensive scale, their operations being, in a great measure, confined to the lathe.

We propose, in this place, therefore, to lay down certain general principles on which depends the goodness or badness of such work, giving only such details as seem to be absolutely necessary for the clear elucidation of the art. When we casually examine any simple piece of carpenter's or joiner's work, it impresses us with the idea that carpentry is, after all, a very simple matter; and so it is, but nevertheless is a *trade* which requires to be not only learnt theoretically, but practised for many years before anything like excellence can be attained. Yet, when we come to details, we are inclined to ask in what lies the difficulty? Given half a dozen square or oblong pieces of planed deal, and a couple of dozen nails of a suitable size, and what forbids to produce a box?

It is just the *correct preparation* of those pieces which constitutes the difficulty. To begin with, the angles of the box, and consequently of the pieces of board to be used in its construction, must be right angles. Each piece, therefore, must be accurately marked out, correctly sawn to a line, and planed up truly on all sides.

Now, if such pieces are cut by a carpenter, these conditions are pretty sure to be fulfilled. If an amateur, not yet versed in the art, makes the attempt, the same conditions are fulfilled *very seldom indeed*. It may consequently be laid down as a rule, that any one who can fulfil the above requirements has learnt the main principles of the art of carpentry. If they can cut and plane up, accurately square, such pieces as require it, they will find little difficulty in making any article they require.

FIG. 91

FIG. 93.

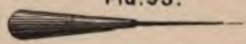


FIG. 92

It is far more easy to plane the flat sides of a piece of board than the edges; yet these are of equal or greater importance, and the best method to work is to mark *both* sides of the piece where it can be done, and cut by chisel, saw, or plane, as the case may be to both these lines.

An example will, perhaps, most fitly serve to elucidate the principles here laid down :—Fig. 91 may represent the sides and ends of a rectangular box, put together with dovetails. The pieces will be probably cut from the same board, Fig. 92, and are to be marked off by a pointed steel scriber, Fig. 93, used against the blade of a square shown in position in Fig. 92. A pencil will make a line on

the wood, but for accurate work a scriber is better, because it keeps its point longer, and makes a finer line. The first piece is marked of the exact length required, if the extreme end of the board has been squarely cut—if not, or if this end will require subsequent correction or trueing, a little is allowed for waste. If all the pieces are consecutively marked before any are cut, all the rest must have an allowance for the saw-cut, that is to say, the waste caused by the thickness of the blade, or the set of the teeth. Thus, in Fig. 92, the lines show the marks of the scriber, the dotted lines the saw kerf always on the same side of the lines, and the latter are to be left, and not cut out by the action of the saw. Those pieces which are to be of equal length are then usually screwed up together in the bench vice, and trued with the plane as if one piece. The advantage of this method is, that the sole of the plane has a wide bearing, and the pieces are therefore more likely to be planed up square and true on the edges—a failure in this respect being fatal to good work. For greater accuracy in planing the ends (across the grain), for which a special plane is used, a second line is drawn with the scriber and square, just within the rough edge produced by the saw, to which line the board is accurately planed. If a similar line is drawn on the opposite side of the board, at exactly the same distance from the edge, and the wood is planed to both marks, the edge will be rendered truly square, unless the two flat sides are very incorrectly faced. It must be remembered in every case that the correct preparation of the component parts of any work is of paramount importance. No subsequent operation will make up for inaccuracy in this respect, nor is it possible to make a good joint, either dovetailed, mitred, or nailed, unless the amateur has first learnt to work accurately to a line, and to square up the edges of a piece of board.

Another point may also be noted in this place, namely, the importance of not cutting off the lines marked as guides for the saw, plane, or chisel, until after the pieces are fitted together. Once lose your landmarks, and you no longer have any guide for such trimming and adjusting as is generally required after the main work of planing and fitting is done.

Supposing the pieces accurately cut out as above directed, the *dovetailing* is then proceded with. If it be a box that is required, the pins of the dovetails are generally made in the two end-pieces. Let these be represented in Fig. 93^B. With the square and scriber draw a line across the board at each end, and on both sides, as far from the edge (and a trifle more) as the *thickness* of the stuff used, as A B. Mark off with compass the points *e f g h*, and those on the narrow end of the pins, and also rule the lines *a b c d*, and those on the other side of the board *e f g h*, *parallel with the sides of the board*, and as far as the line A B. Connect these to form the pins as shown. There is no absolute rule for the shape of these or their number; sometimes they are wide, sometimes narrow and

FIG. 93^B

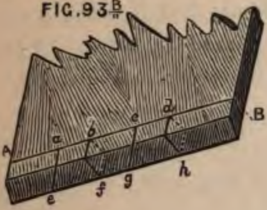
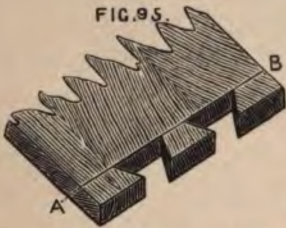


FIG. 94

FIG. 95.



numerous. They should not be *too angular* if of deal, as they are apt to split off and make bad work, and the outside spaces A B, Fig. 94, should be rather wider than those between the pins.

It is always well to mark each piece in respect to the place it is to occupy in the finished work. The face shown in the last two figures is the *outside*, the largest faces of the pins of the dovetails being inside the box. Fig. 94 shows the pins after the intermediate stuff has been cut out by the saw and chisel. It will now be necessary to proceed to the formation of the dovetails, which have to be cut in the front and back pieces as follows :—These are

represented in Fig. 95. The line A B is drawn as before on both sides, but exactly at the thickness of the wood from the end. The piece on which are the pins is stood upright upon it, with the *broad* side of the pins upon the line just drawn. The scriber is then used to draw close round these pins, so as to mark out their exact shape upon one side (the *inside*, which should be labelled as such). With the compasses it will be better to transfer the measurements and lines, so as to mark the form of the dovetails on the other side also. This is to insure the edges on those internal sides of the dovetail formed in the thickness of the wood, being cut at right angles to the two flat sides. It need hardly be mentioned that the dovetail, or thin saw with brass back, is to be used where possible, and a *sharp* chisel in other places; but it *is worth while* to state that on *no account are the lines made by the scriber to be effaced or cut into*, or the pins will be too slack in the dovetails. The inside of the latter, too, on the line A B, must on no account be convex or rounding, but either quite flat and square with the face, or slightly hollowed, so as to insure the close contact of the joint upon the line A B. It is plain that if this is not attended to, the finished box cannot be either strong or shapely, for nails are not to be used, *nor putty*, which may be called the slovenly workman's friend.

Dovetailing is so neat and strong a method of joining pieces at right angles, that it should be practised frequently. Any odds and ends of pieces of board of different thicknesses can be profitably used up in this way. Before proceeding to speak of other kinds of dovetailed and mortised joints (most useful these to our amateur organ-builders), we shall give a little advice in the matter of tools. It is of paramount importance that, however few or many there may be, they should be of good quality. To those residing in London, Manchester, or any such large town, all that need be said is, go to a first-class shop, a regular tool-shop, and not to an ironmonger. To those in the country, sad experience compels me to say, eschew local tradesmen, and send to London, to Holtzapffel, Fenn, Buck, or other such trustworthy shops. Those named keep no bad tools that I am aware of; at any rate, I never

found one at either place. In spite, moreover, of frequent advice to the contrary, I feel half-inclined to add, buy a toolbox fitted, *if you go to either of the above dealers.* If not, get a box made to take the following tools, and keep the latter clean and bright, and always sharp and ready for use. Amateur's tools are seldom in even fair condition, and hence *of necessity* the work done is rough and bad :—

One Hand-saw.—22in. to 26in. long. If not to fit into a chest, the longest will be the best.

One Tenon-saw.—This, if of medium size, will do instead of the next.

One Dovetail-saw.—Which is a diminutive of the last.

One Keyhole-saw.—May be used to cut curves, but is inferior for this purpose to the next.

One Turn or Sweep-saw.—This has a frame of wood, and very narrow blade.*

One Jack-plane, One Trying-plane.—The first may answer for both; but for first-rate work the second, which is longer and kept finer set, is necessary, and also for very long joints.

One Smoothing-plane.—This is a small single-handed plane, useful for finishing off work. It is no use in planing a long straight edge, as it can dip into hollows and rise over hills, while seeming to plane a true surface.

One Square.—One of the *sine-quâ-nons.* Let the blade be 6in. to 9in. A small one in addition is handy, but not essential.

Chisels and Gouges.—Mortising chisels from $\frac{1}{4}$in. to 1in., and paring chisels from $\frac{1}{4}$in. to $1\frac{1}{2}$in., or even 2in., and two or three gouges, will be found indispensable. If it is necessary to use blows with these, let them be always given with a wooden mallet; a hammer damages, and splits the handles.

One Mallet.—Those with iron head sockets, plugged with box-

* The larger frame-saw of similar shape to the above is commonly used abroad in place of the hand-saw. A friend of the writer, who has practised carpentry in Germany, says it is so superior in ease and speed of work, that he now invariably uses it instead of the hand-saw wherever the frame does not prohibit it.

wood, are small and handy, but not suitable for any but light work.

One Heavy Hammer and One Small ditto.—For small nails and light work, a heavy hammer is useless.

One Scriber—Already described.

One Spokeshave.—A kind of plane for hollows, and of very extensive use.

Three Gimlets and Three Brad-awls.—Three sizes of each. Twisted American gimlets do not split wood, but for oak and hard work the old pattern is the best.

Three Augers.—Three sizes, ½in., ¾in., and 1in., and perhaps another 1½in. for large holes.

One Brace and Bits.—A very useful set of thirty-six bits of various kinds, for boring holes, with often a rimer to enlarge holes in metal; a countersink to let in screw heads, and not unfrequently a screwdriver.

With the above alone a very extensive and varied amount of work may be done, and even of these the regular set of brace and bits may be replaced by a plain iron brace, fitted with half a dozen centre-bits of assorted sizes; but if chests of drawers, cabinets, and such like, are to be attempted, or, in any case, if the purse will bear it, there should be added to the above—

A Skew Iron Rabbet (rebate) plane.

A Plough with a dozen Irons.

A Pair of Match Planes.

The cutting iron of the first, which is a very narrow plane, compared with the jack or smoothing plane, is fixed at an angle instead of square across the stock. In this position it will cut across the grain, which is often necessary in forming a rebate (a rebate is a rectangular groove, a recess such as the glass lies in a window or picture frame). Another plane, called a side fillister, will answer for rebating and grooving, having stops to regulate the depth and width of the cut. It is, however, more costly, and much can be done with the common rebate plane.

Axe.—If only comparatively light work is contemplated, a small single-handed axe should be had, but it is excessively disagreeable

to find this tool, from being too light, springing off the work, and the reader is strongly advised to err on the side of overweight, rather than on the other.

Gauge.—There is the simple gauge with one point, and the mortise gauge with two, that can be separated to any given width. The last is solely for marking mortises: the first will do this almost as well, besides being useful in other cases. A simple gauge, at any rate, should be had.

Oilstone.

There is no occasion to add to the above tools, unless veneering or moulding is to be done—for the latter, a special plane, with a set of variously-shaped irons (of the special pattern *reversed* of the design to be cut), is required, and a beading plane or two, the irons of which have semicircular hollowed edges, forming a raised bead. In describing some few operations in carpentry, detailed descriptions and drawings of some of the above will be given. It is, of course, as said before, essential to have the tools in a state of constant excellence, and a few remarks will be made on grinding and setting them. Of oil-stones, the writer prefers the Arkansas, a white American stone, which, if good, cuts rapidly and finely. A *good* Turkey oil-stone is rare, and accordingly precious.

SHARPENING AND SETTING TOOLS.

If a chisel or plane-iron belonging to a *good* carpenter is examined, the edge will be found to take the form of Fig. 96—that is to say, there will be a long bevel formed by the grindstone, and a smaller and brighter one at a somewhat more obtuse angle due to the action of the oilstone. In the figure these are simply exaggerated a little to render the form clear, but it is to be noted that the faces of them are *flat*, not rounding. The larger bevel, is, indeed, somewhat hollow, owing to the form of the grindstone, but the smaller is entirely a level surface. The next figure displays the edge of a similar tool badly sharpened; there is no level face, nor are two distinct planes seen, but the whole of the bevel forms

a curved or rounded surface totally unfit for the production of good work. Now this error is due to the natural movement of the arms, which tend to bring the tool into varied angular positions upon the oilstone, the angle being greatest when the tool is nearest to the operator, and least when at the greatest distance, A B C, Fig. 98, in which the workman is supposed to be standing at D. This habit must be overcome by patient practice, the principle being

FIG. 96.

FIG. 97.

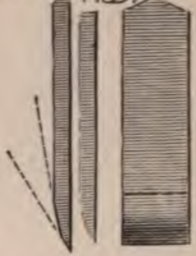
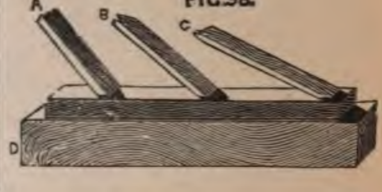


FIG. 98.



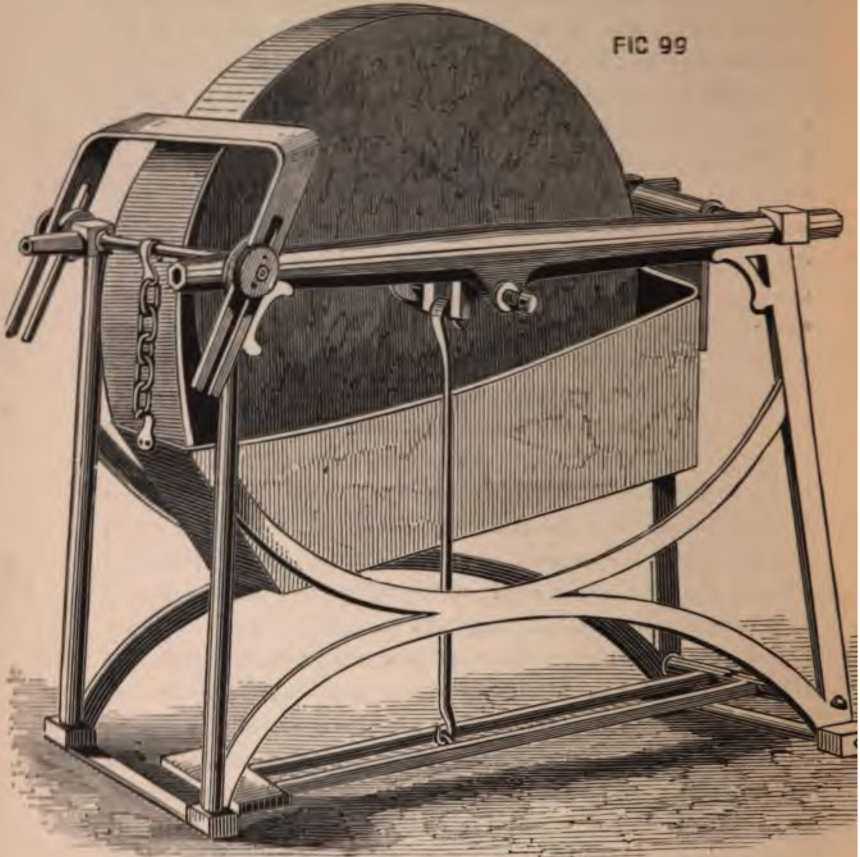
understood. It is evident that the tendency to be aimed at is the raising the handle *slightly* as the tool moves further from the person, instead of allowing it to take the positions shown; all *guides* are to be discarded, both for the grinding and setting. They are as bad as corks and bladders in teaching a person to swim, for it becomes exceedingly difficult to do without them, and it is evident from the daily practice of carpenters that, however difficult the right method may be to acquire, it is by no means impossible, and is moreover of absolute necessity. Square the elbows, let hand and arm have freedom, grasp the tool above with the right hand, so as to bring the fingers underneath it, and let the fingers of the left lie together and straight upon the upper side, their ends tolerably near the edge of the tool, the thumb being underneath. The tool will be thus held firmly and also under control.* Stand square at one end of the stone (which should be

* Holtzapffel gives a different way, the reverse of this. He says the first finger only of the right hand should be above, and the thumb and rest of the fingers below, the left hand grasping the right, with the finger above the tool and thumb below. It is probably in great measure a question of habit.

rather on a low than high bench), and having wiped it clean, pour upon it a few drops of good olive oil, and after a little careful practice success will be certain. A correspondent of a mechanical journal has lately suggested the use of paraffin instead of oil, the stone being first carefully freed from grease. The writer tried it; but, to say nothing of the disagreeable smell, he does not think any advantage is gained by the use of this liquid. Neatsfoot oil is also said not to thicken upon the stone (it is thick enough naturally in cold weather), but the flask oil is, after all, probably the best, and is generally used; sperm oil is also limpid, and much used for sewing and other machines. Of the various kinds of stone offered for sale, no doubt a good Turkey oilstone over 2in. wide—in fact, as wide as can be obtained—is the best. But it is very difficult to meet with one neither too hard nor too soft; and not unfrequently a stone otherwise good will be found to have a spot in it harder than the rest, over which the tool slips, and which soon forms a lump above the general level of the surface. Upon such a stone no tool can be brought to a good edge; and a very hard stone, again, grinds so slowly as to waste time and labour sadly. After trial of various kinds the writer finds the Arkansas, if carefully selected, answer, as above stated, all purposes admirably. It cuts keenly, and, if selected of not too coarse a grit, will speedily put a fine and smooth edge upon any tool applied to it. In the country it is sometimes difficult to meet with, but Fenn, of Newgate-street, or Buck have large supplies, and can always be trusted to select for any amateur living at a distance. Gouge slips are also obtained of the same stone. We have hitherto said nothing of the grindstone, although it necessarily precedes the use of the oilstone. For planes, chisels, and similar tools nothing can exceed a good bilstone, 24in. at least in diameter, and $2\frac{1}{2}$in. or 3in. in width. Such a stone can be mounted upon an axis with a 3in. crank and used with a treadle, being heavy enough to continue in motion, notwithstanding the pressure of the tool, even when the latter is a broad plane-iron. It is necessary to use water; consequently, the stone must have a trough beneath, and this should be hinged at the further end so

that it can be elevated by a wedge beneath, or suspended at the free end. The water poured into this can thus be raised to touch the stone when in use, and lowered out of contact when the grinding is finished. The stone must not be left to soak in the water.

FIG 99

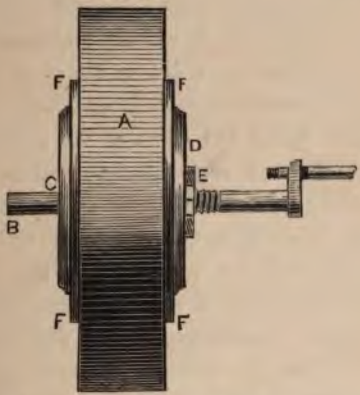


Attached to the frame of the grindstone, and capable of some little adjustment as to height and distance, must be a strong rest of wood or iron to assist in supporting and keeping the tool firmly in position. The Fig. 99, from Holtzapffel, will show at once the best form of mounted grindstone for the amateur's use, although he may

fit up one on a similar plan at a considerably lower price than is charged for the one shown. Let it be observed, however, that a stone badly mounted, and which does not run truly, is not only a disgrace to the owner but absolutely useless. The greatest care, therefore, should be used in first setting it up and in afterwards keeping it in order.

If the amateur can spare time and a few extra shillings, let him by all means discard the clumsy square axle and wedges. Let the central hole be plugged with a piece of boxwood bored truly at right angles with the flat face of the stone with an augur, and let

FIG. 100



the round axle be made with a fixed and a movable flange, as in the Fig. 100, where A is the stone, B the axle, with flange (C) fixed, and a second (D) made with a central hole, to enable it to be screwed against the stone by the nut E. F F are washers of willow or other soft wood to increase the grip of the flanges. This is the method recommended by Holtzapffel, especially for large stones; and although it is by no means impossible to mount them truly and firmly with square axle and wedges, the other method is so vastly superior as to be well worth the additional cost. If one end of the axle is made into a crank to use with a treadle, it is a good plan to have the opposite end squared for the purpose of fitting on an ordinary winch-handle, which may be sometimes

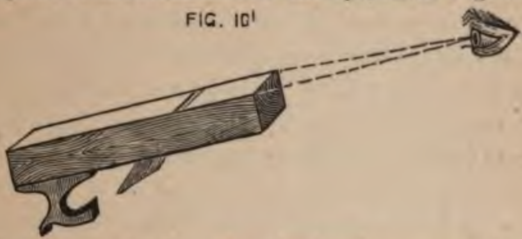
necessary when the work is heavy, especially in turning the stone true with a bar of steel, when, from unequal use of its surface, the latter has become uneven and out of round.

In grinding plane-irons, chisels, and similar tools, the stone should turn towards the operator, and the tool should be held very firmly and quite squarely upon the stone at a point sufficiently near its upper part to allow the tool to be in a nearly horizontal position while its bevel lies flat upon it. If it is held too low, so that its handle points downwards, the water from the stone will run down the hands and arms, which is decidedly disagreeable, especially in winter. In addition, the tool cannot be so firmly held, nor the work so readily seen. Gouges may be ground in a similar position, or (which is more easy and less likely to damage the stone) at right angles to it, *i.e.*, in the same direction as the axle; they must be rolled over backwards and forwards as the operation proceeds. Keep the edges of the stone in use by constantly traversing the tool across its face, and never try to hurry the work by grinding to a more obtuse bevel than that made by the manufacturer. This is, indeed, generally rather more obtuse than it ought to be, and carpenters reduce this angle, and then the second bevel formed by the oilstone (as already described) restores it correctly. In grinding planes and chisels, especially the first, it is as well for the amateur to make use of a square to test the correctness of the edge, otherwise the latter may not be truly at right angles to the side of the tool.

The Use of the Plane.—Much of the difficulty which amateurs experience in using the plane arises from the latter being badly set for work. If either corner projects beyond the general level of the sole of the plane, this will necessarily score grooves or channels. Hence the extreme angle should be slightly rounded off in sharpening the tool. The same deleterious effect will be produced if the plane-iron is not ground truly square, and hence the caution already given on that point. The smaller or break-iron, whose office is to bend up the shaving somewhat sharply to insure the cutting of the other iron, and to prevent its splitting off the surface of the work, should be so placed as to come within

one-eighth of an inch of the extreme edge of the cutter for rough work, and within one-twentieth for finer or finishing work. The two should then be placed in position, so that the edge projects the smallest possible degree below the sole. The position can only be determined by looking carefully along the bottom of the plane, with the point of the same next to the eye, as in Fig. 101. The

FIG. 101



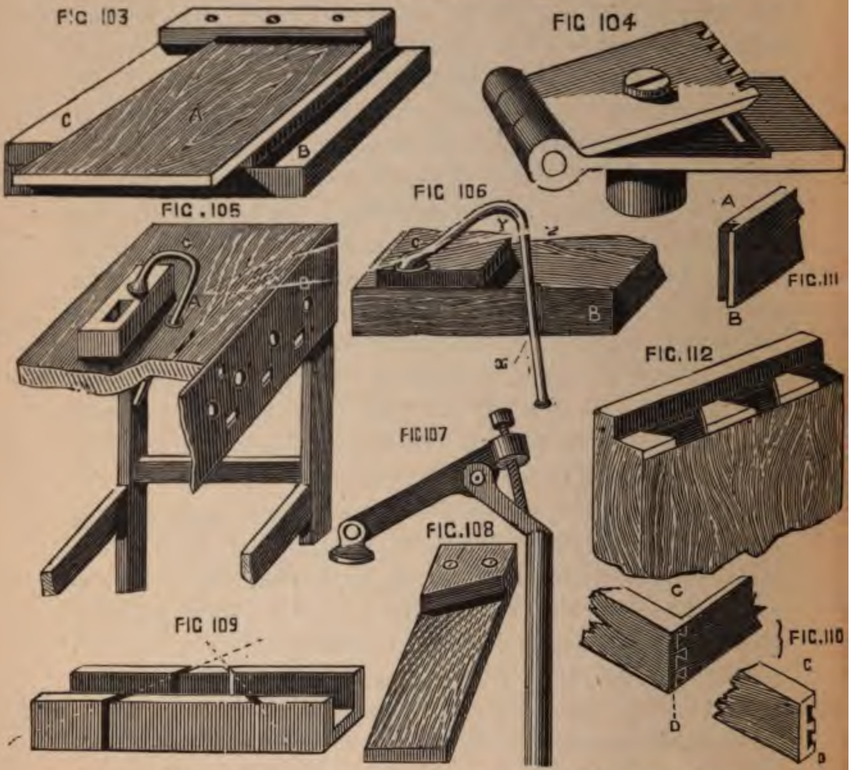
edge will, if correctly formed and placed, appear quite parallel with the sole. It is then ready for use. The same rule applies to the small as to the large planes, except that in the jack-plane the iron projects rather more, as it is used for roughing down a surface. The trying plane, which is longer, and intended for edging boards which are to be joined lengthwise, is always very finely set, and the mouth is narrow. The break-iron is also set very close down to the cutting edge. The longer the plane the more accurately level and true will be the work done by it. The jointer plane is thus still longer than the trying plane. That used by the cooper for jointing the staves of casks is longer still, so that it is leant against a stool or other support, and the work itself is taken in hand and moved to and fro along its sole. As it will be useless for the amateur to attempt the construction of any work, except of the roughest character, until he can plane a piece of board accurately on all sides, keeping the edges square and and sharp, the greatest attention should be given to the use of this tool.

It has been once or twice proposed by different writers in the "English Mechanic" to add a guide to the ordinary jack or trying plane to enable the workman to insure accuracy in planing edges of boards at right angles to the sides. It is probable, nevertheless, that the method commonly followed of having these guides unattached and distinct, forming "shooting boards," "mitring

blocks," and "mitre boxes," is the best adapted for the required purposes. They are at any rate of simple construction, can be made to suit any special work in hand, and, being in no way attached to the tool, the latter can be used for ordinary purposes without alteration. These guides, with the mode of using them, will be referred to again presently. Of late years, planes entirely of metal, as well as those of wood with metal soles, have come into use, but by no means so extensively as might be supposed from their real excellence. It takes long to persuade the country carpenter that he may leave the old "groove" with safety and advantage to himself and his work. Where a fair trial has been given however to the above tools, their superiority has been quickly recognised. A builder of experience, known to the writer, carries one of the small smoothing planes in his pocket constantly, and although it is but a doll's tool in appearance, he uses it extensively in nicely adjusting the fit of work of various kinds, and as it can be set exceedingly fine it answers for planing across the grain at the ends of boards quite as well as the plane with skew iron intended for such work. Of course such tools must be carefully preserved in working order, especially as they are more costly than wooden ones, but for neat work the amateur will scarcely regret the purchase; for organ or harmonium making especially, where accuracy is indispensable, they may be safely recommended to our readers. The shooting board for squaring up the edges of pieces is made by simply screwing two boards together, placed flat upon each other, the under one projecting so as to form a rebate as a guide to the sole of the plane, and to its side upon which it rests during the operation. In Fig. 103, A is the board to be edged, B the lower, C the upper board, D a piece nailed across as a stop. The plane (jack or trying) being laid on its side, the edge will come against that of the shooting board, and no difficulty will be experienced in using it in this position. It is of course essential that the shooting board should be accurately made, and that it should not be liable to warp. In use it is itself laid against the planing stop of the work bench, and the work may be held by the bench hook, to be presently described. A good work-bench is of great importance; it

should be strong and proportionately heavy, with a good thick plank for the top that will hold firmly the planing stop, bench hook, and such like. For the first of these has appeared (as a substitute for the old block of wood with projecting points, commonly made with a few nails or tenter hooks) an iron planing stop, Fig. 104. This is a great improvement upon the old plan, and well worth the price, 3s. 6d., charged for it. Of bench hooks or holdfasts there are two kinds. The first, Fig. 105, has been in use from time immemorial for holding down firmly upon the work-bench pieces requiring to have mortises cut through them. It is a simple affair, and at first sight by no means appears likely to hold anything firmly. The tang or shank A is inserted in a hole in the top of the bench, in which it fits somewhat loosely. The flat part at the bottom of the hook B rests upon the work, which is fixed by a blow upon the head C. If any danger is apprehended of injury to a finished surface, a small piece of board can be inserted to protect it. If Fig. 106 is examined, which shows in section the bench holdfast passing through the top B of the bench, and holding down the work C, it will be evident that the tendency of such work to rise from the bench has the effect of jambing the shank of the apparatus at X X against the upper and lower parts of the mortise or hole through which it passes, and the tendency to lift it from this hole and thus free the work is comparatively small; when it is desired, therefore, to lift it in order to loosen the work, it is accomplished by a blow at Z, on the back of the hook—a similar blow at Y, on the top of the same, tightening it. The improved holdfast, Fig. 107, is on precisely the same system; but the top being hinged to the shank, pressure is exerted by the screw at the back, which depresses the end of the hook. The advantage this form has over the last is more imaginary, perhaps, than real. A pair of such holdfasts form a tolerably efficient substitute for a bench vice, if holes B B are made for their reception in the front board of the work-bench, as shown in Fig. 105. In this position they of course hold equally well, and a plank may be planed on the edge when thus clamped, as readily as if it were secured by the vice ordinarily attached to the bench. The holdfast is also useful

for holding round pieces requiring to be sawn across, and for this purpose it is a good plan to fit one into the top of the sawing bench or stool. To plane long thin slips, or laths, which would bend and break if set against the planing stop, the easiest way is to tack them to the bench at the end next to the right hand by running a brad-awl through and thus pinning them down. In this way, the



action of the plane tends to stretch instead of doubling up the strip, which may in this manner be also planed to the extreme end. Mitred edges or bevels are planed in a similar way with those which are rectangular. For those which run lengthwise of the board, a long planing guide is needed, on which the plane sole, and its side, rest in positions according to the angle required. The drawback to such planing boards is the liability to cut the guide as well as the

work, and when the former is of iron the tool is of course liable to injury. Hence, it will often be found to be the best plan to place the plank edgewise as usual in the bench vice, and with a gauge set to the exact thickness of the same; after it has been planed up truly square, run a fine line on the flat side. If the edge is then bevelled carefully to this line, the desired effect will be produced without any guideboard or mitre block being needed. In large joinery works the mitring and bevelling is done chiefly by circular saws, the work being fixed at the required angle. It is afterwards finished by hand if required, or by a planing machine arranged for the purpose. For planing the angles of picture frames at 45 deg., Fig. 108 is used, but frequently in this case the work is left rough from the mitre saw, to cause it the better to hold the glue used to unite the several pieces. Fig. 109 is another form of mitring guide or box. The saw cuts* are made at the required angle, and the squared strips, or pieces of moulding, for which the apparatus is chiefly used, being placed in position, resting against the further side of the channel, the mitre saw is inserted in the kerf, and the piece accurately cut off, either squarely or at the desired angle. There is seldom occasion to touch the cut edges, either with chisel or plane.

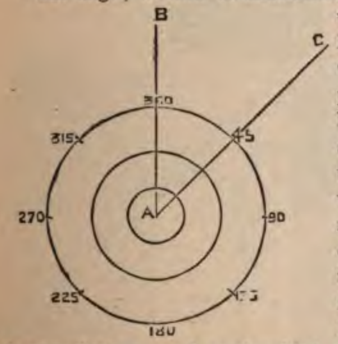
It will be as well to recur in this place to dovetailed joints, of which only one kind has been described, namely, that in which the forms of the pins or dovetails are visible in both pieces thus joined. This is never practised on articles of furniture, unless veneer is to be afterwards added to conceal the joints. Fig. 110 represents the corner of a drawer as commonly made, on which, although the dovetails are seen at the side when the drawer is open, they are entirely invisible in front. The latter having been planed up square and true, a line C D is made with the gauge on both ends of the same to mark the portion which is to be left uncut. The sides (of much thinner stuff) are then planed up, and the dovetails marked and cut as shown. This is then laid in place, with the extremity accurately adjusted to the gauged line, and with a finely pointed scriber the dovetails are traced upon the ends of the front of the drawer, which thus contains the pins. These cannot be

* Made too wide in the drawing; they are merely as thick as the saw blade.

sawn, but must be cut with a sharp chisel down to a second line, made with the gauge set to thickness of the side pieces. Again the amateur is warned to leave all lines thus scratched, and in nowise to cut them out in the preparation of the several pieces. Instead of only concealing the dovetails from the front piece as in a drawer, they may be so constructed as not to appear at all, and the only sign of any joint will be a fine, almost imperceptible, line on the angle. Even this will not be seen after the finishing and polishing is done. Let the pieces be first rebated out, as A B, Fig. 111. The pins and dovetails are then to be cut with a chisel in both parts, below the rebate, which is then to be cut to a mitre. This is not only the neatest plan, but requires care, and is the most difficult to manage, because the pieces cannot be fitted together until the mitring is also done. An easier method, and one almost equal in appearance, is the lap dovetail, in which only one piece is rebated, but the dovetails in the other are not cut through, Fig. 112. In this case no such difficulty occurs in marking and cutting the pins which are made in the rebated piece, and the pieces can be tried in their places with ease, as in common dovetailed work.

There are other modes of uniting pieces at right angles, and even the simple mitre joint is greatly used, in which each piece is planed to an angle of 45° and glued. After being placed together, two or three fine saw cuts are made through the angle, in opposite directions, and slips of veneer inserted, which when the work is dry are cut with a chisel flush with the sides of the work. These are not then unsightly, and the joint is sufficiently strong for most purposes. A great deal of work—generally all but boxes, drawers, and such like—is joined up by ordinary mortise and tenoned joints. It is unnecessary to describe the mode of doing this, further than by the illustration, Fig. 113. The tenon and mortise are to be marked with the aid of the square and gauge on both sides. The mortise is cut half from one side, and half from the other, to insure its being made at right angles to the upper and lower surfaces of the wood. Figs. 113^B and 113_C show the method of wedging up such mortised joints. The mortise is first cut straight

through the piece and afterwards sloped off, as seen in 113[B]. A small wedge is then brushed over with glue and driven in on each side of the tenon, to which it adheres, and when dry it is impossible to separate the pieces without breakage of the wood itself. In larger work this joint is generally pinned through the side with oak trenails, as shown in 113[C], instead of being fastened with wedges. If it is purposely intended to place the two pieces at other than a right angle, the square is replaced by the bevel, Fig. 114, generally made by the workman of wood, like a shut-up knife, but without a spring. A superior form, Fig. 115, is made with a metal blade, the joint in which is formed with a slot, as shown. This bevel is very convenient, being capable of more extensive adjustment, the slot enabling the instrument to be used as a T-square or T-bevel, the whole of the edge coming into use, and thus, too, the larger angle, A B C, can be measured and set off on the piece instead of the smaller, which may be at times con venient. In this place it will, perhaps, be to the advantage of the reader who is ignorant of mathematics, to set forth a few simple facts concerning lines and angles, which will often simplify the process of setting out work. When straight lines cut each other, as Fig. 116, the two smaller angles, *a a*, are equal, and the two larger, *b b*, are also equal. The four together equal four right angles* of $90° = 360°$ (see foot-note), and



* An angle, it must be understood, is the *corner* (Lat. : *angulus*) formed by the meeting of two lines at a point. The length of the lines has nothing to do with the size of such angle. If a pair of compasses are opened, the legs may be of any length, the longer they are the further apart their points will be, but to enlarge the angle at the joints you must open them wider. This results from the fact that an angle is measured by a circle, always divided into 360°, no matter what may be its size. In the diagram the angle at A formed by the meeting of the lines A B, A C, is 45°, extending these lines they reach the second or the third circle, but still they point to 45° upon its circumferance, which is the measurement of the angle.

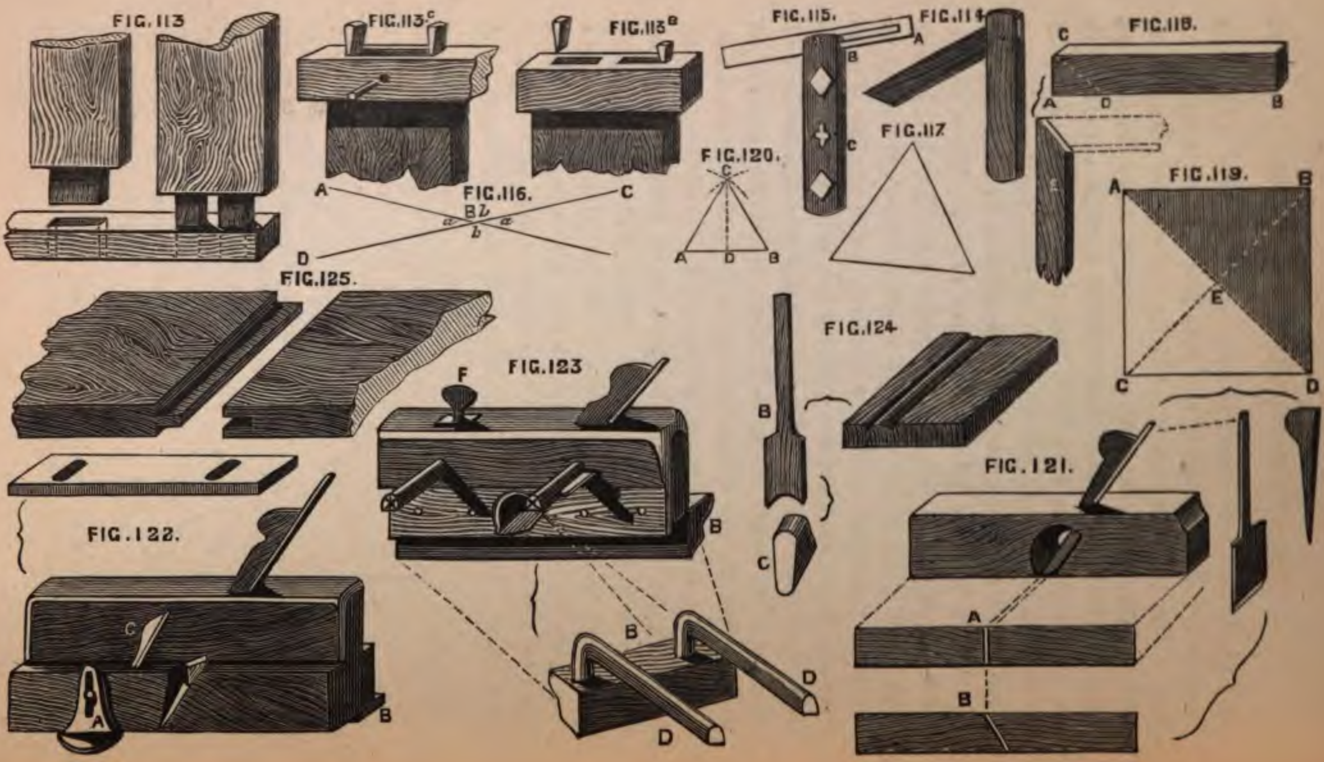


FIG. 113
FIG. 113^C
FIG. 113^B
FIG. 115.
FIG. 114
FIG. 118.
FIG. 116.
FIG. 120.
FIG. 117
FIG. 119.
FIG. 125.
FIG. 123
FIG. 124
FIG. 121.
FIG. 122.

any two adjacent (side by side) angles equal two right angles, or 180°. Hence, as much as A B C is more than one right angle, so much is A B D less than one right angle. (The middle letter of three by which an angle is generally expressed is placed at the angle.) If, therefore, A B C is an angle of 135°, A B D must of necessity be 45°, because 135 added to 45 make 180, equal to two right angles of 90° each.

Angular measurement is always of such vast importance—being the basis of astronomical and engineering measurements, and of such extensive general use—that the few elementary lessons given here should be thoroughly learnt and understood, as well as the following:—Every triangle, Fig. 117, with equal sides, has also three equal angles, each of sixty degrees (60°); consequently, the three angles together equal 180°, or two right angles; and this statement is equally true of the three angles of any triangle, because, if one of these is made less, one of the others must be just so much greater, as will be readily seen if practically tried. In sawing a bevel to form a mortised joint, as for a picture frame, directions have been given to measure on the length A B, Fig. 118, a distance A D equal to the width A C, and to cut from one point so found to the other upon the dotted line. The angle thus formed at C will be 45°, or half a right angle, and thus, when the other piece, being similarly cut, is placed in position (having also an angle of 45°), the whole angle thus formed will be 90°, or a right angle, which is precisely that required, and is the angle of a carpenter's "square." Now a square properly so-called is a figure of four sides, all equal, and containing four angles, also equal. Let us briefly examine such a figure. Fig. 119 is a square. The lines dotted are called its diagonals (a Greek word signifying across the angles),* and one such diagonal evidently divides the square into two equal triangles. Now the diagonal A D divides exactly in half the angle at A, and the angle at D; and as these were both right angles of 90°, it follows that the shaded triangle, B A D, has at B an angle of 90°, and at A and D angles each of 45°. This will prove what has been stated, that the three angles of the triangle taken together equal two right angles

($90^{\circ}+45^{\circ}+45^{\circ}$ equals 180°). This figure again will teach us another truth, or rather prove another already stated, "that when two straight lines cut each other the angles at the point where they cut equal four right angles." Take the small triangle E C D. The angles at C and D are each 45° (half the right angles at the corners of the square), then if it is true that the three angles of a triangle are together equal to two right angles, the angle at E must be a right angle (for we have taken from the triangle the two angles C and D, each of 45°, and together 90° or one right angle, and so the one left must be the other), and we might take in turn each of the four small triangles in the same way, and thus should find at the point E, four right angles, as stated. It will thus appear that it is easy in many cases to draw two lines at a desired angle by very simple means—namely, with the ordinary two-foot rule and compasses alone. If an angle of 60° is required, it is only necessary to make a triangle of three equal sides, which is readily constructed as follows: Draw a line A B, Fig 120, six (any number of) inches in length, open a pair of compasses to that width and with one point at A, describe with the other an arc (part of a circle) as shown. Do the same from the other end of the line, and it will be found that the second arc cuts the first, and from the point at which they cut each other draw lines to the ends of that first drawn. You now have a triangle with equal sides, and each angle of 60°. Divide the base line exactly in half and draw a line as dotted. This will divide the top angle into two exactly equal; you now, therefore, have an angle of 30°. At the point D, too, you have thus raised a line, D C, perpendicular, or at right angles to A B, each angle at D being 90°, and thus another useful lesson in Geometry has been learnt. Similarly, that useful angle of 45° has been shown to be obtained by drawing diagonals to a square, the latter being practically drawn by using the tool called by that name, though it can be drawn also by ruler and compass. Time is never lost by devising all sorts of problems with these two simple tools, and the more perfect the knowledge thus gained of lines and angles the better qualified will the amateur (or professional) be to plan and carry out all kinds of work in wood, no matter how complicated.

A rebate is very often required in carpentry either down the side or across the end of a board, this being the name (pronounced rabbet) of the recess in which lies the glass in a picture frame or window, or the panels in many pieces of furniture. This is formed by a narrow plane, Fig 121, the iron of which is sometimes straight across the sole, as in the first figure, A, but very generally set askew, B, in which position it will plane across the grain, as the edge meets the fibres at a somewhat acute angle, and consequently cuts instead of tearing them up. A practised hand does not require any guide or stop to insure the straight run of the plane at the desired width from the edge, some of the fingers being placed beneath the tool to act as such. Sometimes, however, a strip of wood is lightly tacked beneath and lengthwise of the sole, to prevent the plane from cutting beyond the desired limit, and if there are many pieces to be rebated exactly to one width this is the best method to pursue. By such means this common and cheap tool is often made to answer the purpose of the more costly side fillister provided with adjustable fences determining the width and depth of the required rebate at pleasure. This plane is shown in Fig. 122, and is a very useful tool in its way, and indispensable to the regular joiner, but not so to the amateur. It will be evident that the fence which slides vertically, A, determines the depth to which it is to cut, while that at B, affixed as it is to the sole, limits the width of the rebate. The iron, C, is simply a cutting point to divide the fibres perpendicularly. Akin to the above is the plough, Fig. 123, which, indeed, set to the desired position will cut a rebate with the grain but not across it. This plane is furnished with a fence B, of wood, which is always parallel to the side of the plane, and is capable of being fixed at a considerable distance from the latter, as the arms D D pass through mortises in the body of the tool, and are fastened by small wedges. A groove may thus be made as far from the edge of a board as this fence can be fixed from the side of the plane—generally, six inches. There is a fence or stop adjustable by the screw I, determining the depth of such groove, while its width depends upon that of the iron selected, a plough being fitted with half a dozen or more. The routing plane and some others being designed for special

work not likely to be undertaken by the amateur, need not be illustrated here, but a word or two may be said respecting the planes used for beading and moulding. These are in appearance like the rebate plane, except that the sole of the tool and the iron itself is filed into the shape of the particular moulding it is meant to produce. That for a simple *bead*, for instance, Fig. 124, is made with a plane, the iron of which is shaped as seen at B, and this has to be sharpened with a slip of oilstone of the section C, which is called a gouge slip. The piece to be thus ornamented is planed up true and smooth, and subsequently moulded by the tool described, a process so easy as not to need lengthened explanation. When a moulding is needed, however, more care is required. The piece is first planed accurately to the width and substance required, and the plane is then applied, *not perpendicularly*, but on a slope, so that, as is evident, the strip may well be, and often is, first planed to such inclination. The reason that the tool is not used perpendicularly to the wood is well explained by Holtzapffel, who points out that although the plane iron is always set at a given angle at which it meets the fibres most favourably for cutting them, the edge and sole of the plane must be parallel to the surface to be cut; as, for example, if a rebate plane be used, it cuts smoothly and evenly the *bottom* of such rebate, but not the *side* of it, and for the latter the plane must be laid on its side. Much of a moulding, therefore, would not be *cut* if the plane were applied otherwise than as stated, that is, with its sole *parallel* to the surface to be moulded, or, in other words, with the plane itself perpendicular to a line representing the general slope or inclination of the surface to be cut into the ornamental form. Even thus applied, the work will generally need a little finishing with sandpaper, because some few at least of its fibres are sure to be more or less abraded or torn up.

While on the subject of moulding and decoration of work, it may be well to call attention to a general rule given, as the writer believes, by Pugin, and which should be observed in designing ornamental work in general. The substance of it is that "*extraneous* ornamentation" which is of no use to the object should be

avoided. For instance, in designing a work-table, the necessary parts are the top and the legs. The latter may be strengthened by cross braces, the top by an edge to prevent warping, and so forth. The legs and these braces, with the edging, may be decorated to any extent; but it is bad taste to add pieces here and there, hanging bosses and such like, which are plainly and evidently of no use at all to the structure, and do not further or extend the serviceableness of the whole; in short decorate all necessary parts, or useful additions, but add nothing merely for the sake of showing how skilfully you can design or execute mere useless ornamentation. This rule is even more necessary for those who are engaged in lathe work, in which there is such unlimited scope for the exercise of ingenuity and taste, but it should not be wholly overlooked in the practice of carpentry and cabinet making.

There are planes specially made for cutting the edges of boards, which are to be united lengthwise, Fig. 125. They are sold in pairs under the name of tongue and groove, or match planes. Not unfrequently, however, both pieces are grooved with the plough, and a separate slip planed up to fit the grooves is inserted. The main object of this work is to prevent spaces occurring between the boards as they shrink in drying. The edges close to the joint are generally ornamented with a bead, Fig 124. This shrinking of the wood, by which the width alone is affected, must always be provided against. It is sure to take place in some degree; and if each edge of the board (a panel or drawer bottom for instance) is tightly glued to the frame in which it is inserted, the panel must of necessity split. Hence the *sides* of panels are never thus glued or nailed, but left loose in their rebates or grooves, when the shrinking can take place without injury to the article.

In *glueing* remember that the best glue is quite clear, thin, and brittle. It should be first soaked in cold water, and then boiled in a double vessel, that it may not be *burnt.* It should be used *boiling* hot, and the *pieces to be united should also be well warmed,* or they will chill the glue as soon as applied. The glue must not be thicker than cream (scarcely so thick as real cream, but nearer what is sold as such in London), and both pieces being brushed

over with a *thin* coat of it are to be rubbed together for a few seconds, placed in exact position, and tied or clamped till dry. Thick glue on cold wood simply keeps the pieces apart, it cannot unite them.

The following recipes, compiled from various sources, will possibly be useful to the reader and may generally be relied on :—

French Polish.—This (and the hard wood lacquers) has for its base a gum soluble in spirits of greater or less strength, and is made thick or thin according to the special use for which it may be designed. The most common (used for varnishing soft wood, boxes of willow, lime, and so forth for druggists) is made with resin and spirits of turpentine; but this being laid on with a brush, is less a polish than a varnish. There are various recipes for making the real French polish, of which the simplest, and perhaps best for general purposes, is composed merely of shellac dissolved in spirits of wine or naphtha. Four ounces to one pint of spirits will be sufficient in many cases, but it is easy to add gum if the polish appears too thin. It is, however, better to use several coats than one or two of a thicker consistency, as the grain of the wood will be more easily seen, and will appear more nearly of its true colour which is generally desirable. The writer has found the addition of half an ounce of sandarach a good addition to the above : it appears to make it work rather more freely; but this or other soft gums must be used in moderation if at all.

Finishing Polish.—This is to be used after the above, as will be presently directed. Best rectified spirits of wine half a pint, shellac two drachms, gum benzoin two drachms. Put these into a bottle, and let the latter stand near the fire loosely corked. Shake it occasionally until the gums are dissolved. When cold, add two tea-spoonfuls of the best clear poppy oil (it can be obtained of any artist's colourman) and shake the whole well together.

To use French Polish.—First, it is absolutely essential that the surface of the work should be as smooth as it can be made. Whether turned or planed it must be highly finished; the latter

especially rubbed down with the finest sandpaper, used in all directions of the grain until the whole surface is of one uniform greyish tint without scratches. The dust caused by the process must now be carefully wiped off with a *dry* warm cloth. Pour into a saucer a little linseed oil, not boiled or thickened with dryers, and have it close at hand. Roll up a soft wad of list, torn from a roll of flannel, or make one of cotton wool the size of a large walnut, or rather larger if the surface to be polished is extensive, and, covering it with a piece of linen, tie the latter where its folds meet. This is the rubber, which is to be applied to the bottle from time to time to be replenished as it gets dry. When thus covered with polish, a second piece of linen rag (old and soft) is to be laid over it, and is to be moistened by just one drop of oil applied with the finger. Pinching together the ends of the outer rag to form a handle to the pad, proceed to rub over with circular strokes a small part of the surface to be polished, not pressing heavily except when it is desired to squeeze out a little more polish from the pad. The outer rag acts as a filter, and prevents any undissolved gum coming into contact with the work as the polishing proceeds. Continue thus to rub until the rag seems to be getting so dry as to endanger scratching the work. Then remove the outer rag, take up a fresh supply, oil the outer rag, and proceed as before until the whole surface is fairly covered. If you desire to make good work, this operation must be carried on in a warm and *dry* atmosphere, and each coat thus laid on must be allowed to become quite dry before it is retouched. Supposing that a second coat has been thus laid on and dried, wait a day, and then with the finest sandpaper rub down the whole surface of the work, which, however bright at first, will have become more or less dull from the absorption of the polish. Then give a fresh coat as before; after which, with a clean rag just moistened with spirits of wine, rub over the whole to remove any dull spots caused by the oil. Let all become dry, and then give a coat of the finishing polish in the same way, using a fresh rubber. If in this last coat dull places should occur, you can generally remove them by more vigorous rubbing, which this finishing polish will bear.

To economise Polish.—Many woods of a porous nature, especially if dark, may have their pores in a measure filled up before polishing, by which French polish may be economised; but in the *best* work, on harder wood than mahogany, this should not be done, nor on woods of a light colour intended to retain their natural tints. Make some size by boiling glue in a sufficient quantity of water to reduce it to the consistency of new milk—in short, the water must be merely thickened by the glue. Spread this with a stiff brush over the work, rubbing it well into the surface, and let it dry; after it has become hard it may be rubbed down with fine sandpaper, and, having been carefully dusted, a second coat may be given, after which (when again quite dry) the polish may be applied as usual. Clippings of parchment or old white kid gloves, boiled in water, also make a good size; and, being of much lighter colour, this may be used on wood on the surface of which the dark glue size would be inadmissible. Either of the above used as directed will save not only the French polish, but much labour. French polishing in the lathe is an easier process, because the revolution of the work in contact with the rubber produces, by the friction of both, the requisite warmth, by which the polish dries almost directly. The labour of rubbing is, moreover, entirely done away, and the polish may be used somewhat thicker in consistency; otherwise the process is practically the same.

Lacquer for Brass.—One pint of rectified spirits, one ounce of turmeric powder, two drachms of best anatto, two drachms of saffron. Let it stand ten days in a warm place, frequently shaking the bottle until the ingredients are dissolved; filter through muslin into another bottle, then add three ounces of seedlac, and again leave it ten days, frequently shaking it as before; let it settle, and it will be fit for use. The articles to be lacquered must be quite free from grease, and must be just too hot to be handled by the fingers. The lacquer must be applied quickly, with a camel's-hair brush.

Another Lacquer for Brass (Holtzapffel).—For pale yellow: one ounce of gamboge and two ounces of Cape aloes, powdered, and mixed with one pound of shellac; for a full yellow: half

pound turmeric and two ounces of gamboge; for a red lacquer: half pound of dragon's-blood and one pound anatto to one gallon of spirits of wine. Use the best pale shellac for the light-coloured lacquers, and the darker when it may be required to produce a darker tint. Another pale gold lacquer is made with eight ounces of shellac, two ounces of sandarach, eight ounces of turmeric, two ounces of anatto, and quarter ounce of dragon's-blood, to one gallon of spirits of wine.

Staining Deal, Beech, &c., to imitate Ornamental Woods.—Some recipes for the above are given in many works, and are more or less effectual. It is, however, now possible to buy them so cheaply, and of such excellent quality, that this method of obtaining them is far preferable. Stephens's wood stains are as good as any. They are all painted on with a brush, and afterwards varnished. One or two recipes are, nevertheless, added which may be relied on:—

Ebony Stain.—Wash first with a cold solution of sulphate of iron, and let it dry; then brush over several times with a hot decoction of logwood chips, to which a few nutgalls may be added; when dry wipe with a wet cloth, and, when again dry, polish or varnish.—Beesley.

Mahogany.—Brush with diluted nitrous acid, and when dry use dragon's-blood, 4oz., common soda, 1oz., spirits of wine, 3 pints. These must stand in a warm place and be frequently shaken, after which the whole must be strained. Use a soft brush, and repeat as often as necessary. The yellow colour used to stain various light woods is made by dissolving turmeric in spirits of wine. This may be added to French polish, or used first; but no stain containing water can be so used, nor, indeed, must any surface to be French-polished be at all damp, or the polish will by chemical precipitation of a part of the gum (which is soluble in *pure* not in diluted spirit) become thick and its transparency destroyed. Varnishes to be used with a brush mostly require processes scarcely within the power of the amateur. They have to be heated in proper vessels; and the operation, even in skilled hands, is not free from danger. In any case they are much better bought at the oil and

colour shops, where they may be had well prepared and of various kinds. Copal, mastic, animé, and amber are the several bases commonly used either alone or combined, and these are dissolved in turpentine with addition of colouring matters, or without, according to the requirements of the coach-builder, the artist, or the mechanic. If the amateur will state the use to which he is about to apply it, the proper kind of varnish for that particular work will be supplied to him with *an appropriate brush*, the latter being important. It is essential to work in a room free from dust, and in a warm dry atmosphere. There is no difficulty in laying on the varnish, but it must be thinly spread so as merely to overlay the work like a very thin sheet of liquid glass, so to speak, through which the veining (or graining) of the wood can be distinctly seen, the varnish not appearing directly as such.

The following are from the "Gas Consumer's Guide," a most useful and handy book by no means limited to such as have the advantages of gas illumination :—

Solder.—To make solder for general use, take two parts of block tin and one of lead; when melted, stir well together, throwing in a little resin; it is not necessary that the resin should be fired; skim the metal and run out in sticks as required. Scrap sheet lead is the best kind for the purpose. If the solder is for blowpipe use, run it into thin strips ten inches long, of sufficient strength to bear its own weight when held straight out, which may be done by using a small ladle with a hole in it at the side; so that when the ladle is tilted and carried forward upon a stone or plate at the same time, the solder flows freely through the hole to whatever thickness is required. Should the solder not show up well, from impurities in the lead or tin, put in a lump of sal-ammoniac and stir briskly. To know by guess if solder is rightly mixed, pour out a small quantity, the size of a crown piece, to cool; when set and it is bright, having a few prominent spots on it, it is right for use. If it has a frosted appearance put in more lead. If dull and coarse looking put in more tin, or if in sticks take it up, listen while bending it, and if it crackles loudly, put in more lead; if it bends softly put in more tin; but when tough and bright, it will do.

To tin Cast Iron.—File the part clean and free from rust, &c., rub it with sal-ammoniac dipped in water, or make a liquid by dissolving sal-ammoniac in water; it can then be applied with a brush, using the copper-bit at a great heat, which must also have been previously cleaned; when floated well, put on a little resin and sweat the solder well about the part tinning; it will not be a sound job unless the iron is at a good black heat, though it apparently looks so.

To tin Wrought Iron Piping, &c.—After filing and cleaning the part properly, use "spirit of salts" (not *killed*), and when covered well with solder put on a little resin and again sweat it with the soldering iron. This is applicable for zinc and galvanised iron, but for sheet tin and new iron use *killed* spirit of salts, which is prepared thus: Put about one gallon of "salts" into a pipkin or bottle; cut up thin scraps of zinc, and put them into the salts; chemical action then takes place, giving out plenty of gas (which, if lighted, will burn, making slight explosive reports). When there is no longer action between the zinc and salts, add a little water, and it is fit for use; whenever used in soldering, wipe off with a wet rag, for if left on, it will destroy the iron.

Various Substances used for Smoothing and Polishing Metal and Wood.

Dutch Rush.—This is the *Equisetum Hyemale* or Rough Horsetail, of which there are several varieties, all more or less impregnated with *silex* (flint) in their outer coatings. That called by the distinguishing name of *Hyemale* contains not only more of this substance but in a more compact state, rendering it more durable and better able to stand the rubbing action used when wood or metal is to be smoothed by its means. Holtzapffel speaks of this kind as growing in Scotland; but Mr. Moore, in his valuable work on "Ferns and their Allies," says it is brought from Holland, where it is planted along the dykes to support the earth, which it does by its matted roots. The rush is the size of a writing quill, and feels rough, like glass-paper. It may be used on metal as well as wood.

Sand and Glass Paper or Cloth used to be made frequently by the amateur, but is now readily purchased. The cloth or paper is merely glued and fine sand or pounded glass sifted over its surface. This is now done very rapidly and evenly by machinery designed for the purpose. Emery is used very largely and in various ways for polishing metal, and is also brought into use as a sharpening or grinding agent. The emery stone is first pounded and broken into lumps, and eventually by grinding brought into the state of a powder containing the substance in larger and smaller particles mixed; and these have to be afterwards sorted according to their several degrees of fineness. This is done on a large scale by washing; but any size of the emery of commerce can be further separated into sizes by hand washing, and this is in many cases a matter of necessity, especially for polishing the lenses of telescopes and similar important work. The principle is the same as that on which depends the washing of sand for gold, the latter sinking to the bottom of the basin or tank more rapidly than the former, by reason of its greater specific gravity. The emery is thrown into a large basin with plenty of water, and the whole well stirred so as to disperse the metal throughout the liquid. At the expiration of (say) ten seconds the coarsest particles will have subsided to the bottom, when the rest is quickly but steadily poured off, and the residue placed by itself in another vessel. The emery and water are again stirred, and after ten seconds the residue is again parted and added to that first obtained. This is repeated until at the end of ten seconds none subsides. A longer time is now taken, twenty or thirty seconds, when by the same process the next coarsest size is separated, and so on until at last the finest possible powder is obtained. Each size is kept separately, and the finest most carefully guarded from admixture. Emery is used with water, oil, or in its dry state. With oil it does not *polish*, but leaves the metal smooth and dull. When water is used, the article must afterwards be carefully dried if of steel or iron to prevent rust. A good polish is thus obtained. For brass it is best to use the emery first with oil, and after cleaning it off thoroughly to finish with dry emery, but

brass must be lacquered to preserve its polish, and give the high finish generally applied to this metal. In polishing with emery cloth or paper the edges of the work are very liable to be rounded, which is in many cases to be avoided. To this end a piece of deal planed up square, or in any more convenient shape, is covered with a coating of thin glue and dusted with powdered emery. When dry a second or third coat may be similarly added. Emery sticks thus made are exceedingly useful, and, not *wrapping round* the edges of the work like paper and cloth, the angles are easily kept sharp and square. For flat plates a square piece of wood half an inch thick, with a knob on one side to serve as a handle, the other being coated as described, forms a very efficient tool. Latterly emery has been consolidated to form small grindstones of various-formed edges for particular work. Those sold with sewing machines for grinding needles are very convenient for many purposes. They require of course some kind of lathe or other machine for putting them into rapid motion. They are wonderfully durable, and most desirable in every way.

Rotten Stone is a good material for polishing brass and other metals. It is a soft brown, or brownish grey substance, and is used generally with oil, though sometimes vinegar is used to moisten it.

Putty Powder is the name given to oxide of tin, and is prepared by fusing the metal in an iron muffle with free access of air. The lumps thus formed, which are very hard, are afterwards ground to powder. The lighter the colour the better is the quality, the impurity being adulteration with lead. This substance is used to polish glass as well as metal.

Crocus, Rouge, Plate Powder.—These are oxides of iron, prepared from the crystals of sulphate of iron by ignition in crucibles. Carefully prepared they will polish the finest work without scratching it. It is not worth the amateur's while to prepare these; but he can, perhaps, by washing as described when treating of emery, obtain finer qualities than those ordinarily sold. Some of the latter are mixed with oxide of mercury, which is highly destructive to gold and in a less degree to silver, although it may at first improve

the appearance of the latter metal. Crocus may be used wet, and the work finally polished with a chamois leather and dry powder.

Note.—The amateur mechanic must take care not to fall into the too common mistake of polishing unfinished work to make it appear better than it really is, because, in the first place, no one, whose opinion as a mechanic is worth having, will be misled, thereby, and, in the next place, no real gratification can ensue to the maker. No amount of polish will make an untrue spindle run smoothly in its bearings, or compensate for the unskilful use of the file, chisel, or plane. A piece of machinery, mechanical model, or otherwise, in which the several parts are accurately adjusted to fulfil each its peculiar office, is always pleasing to the eye of an intelligent artisan, even though each part may bear the marks of file or scraper, because these may evidently be erased at pleasure by subsequent finishing and polishing, and in some cases such polish is rather undesirable than otherwise.

With these remarks "Old File" intended again to make his bow and retire, wishing his readers that success in their manifold works, to which he has done his best to contribute in the few hints thrown together for their perusal in this unpretending Hand-book, reminding all that no amount of book knowledge will give that accuracy of eye and hand which is to be obtained by long and careful practice. The principles have been set forth for their guidance, the rest must depend upon their own energy and perseverance. It having, however, been suggested to him that to add a few words on the lathe would much add to the usefulness of this little guide to mechanical operations, he has again taken up the pen and endeavoured to satisfy the demand.

THE LATHE.

The present little work would, perhaps, hardly be complete without a few words on the lathe, which, of necessity, is found in every workshop in which the multifarious operations of the amateur are carried on. It is, of course, unnecessary to enter upon the description of lathe apparatus used for the production of elaborate works of art, but only to describe such operations as are likely to be required in making models of machinery or similar mechanical works. We shall therefore have to treat of wood and metal turning, requiring only a plain inexpensive lathe and accompanying apparatus. In the "English Mechanic" and other engineering papers are advertisements of many descriptions of lathe, and we may add, of *various qualities*, including good, bad, and indifferent. The prices range apparently from £3 10s., or £4, to any sum the reader likes to imagine, for hundreds are as easily spent in this matter as pounds. Now, it is very doubtful if a lathe *can* be made, worth anything, at the first-named price, for this reason :—The mandrel or spindle upon which the small cone or pulley is fixed, and to the screw at the end of which the work to be turned is to be attached, must be not only itself true and straight, but must be also hardened, and in this latter process mandrels often warp or crack, or become otherwise out of truth. The collar (or collars, if two are used) through which both or one of the ends of the mandrel passes has to undergo the same process, and it is evident that many of these also will be split or warped thereby. Now a good lathe-maker will throw aside those that are cracked or much out of truth, and those of really standard quality alone he will retain, and by subsequent grinding (a tedious process) will fit them for work. The consequence is, that as he has often to reject a mandrel which has already been carefully turned, he must, of necessity, charge rather more for such as stand the test above-named. An inferior maker

seldom runs any risk, because he hardens none, or, if he does, he will make the best fit he can of the warped ones, instead of rejecting them. Again, when a first-rate maker has to fit two such surfaces by grinding, he will use oilstone powder as the medium, another will use emery which cuts quicker, and is consequently cheaper to use, but which embeds itself in the metal, and thus continues to grind when the lathe is in use, thereby causing the mandrel to work loose in its bearings. It is easy to test a good mandrel, so far at least as *hardness* is concerned, for a file will not touch it; while a mandrel left soft will be readily scratched by this tool. Now, the mandrel of a lathe is *the important part:* a bad one is scarcely worth mounting; while a good one, straight, true, and hard, and running on its bearings without the slightest shake, is worth a great deal, and especially so because it will remain good for fifty years or more, and is worthy of being fitted with all kinds of costly apparatus. There is another matter worthy of note in respect of mandrels. Do not get a heavy, clumsy-looking affair, nor one which has a long bearing in the collar. It is sure to work heavily, and, besides, it will never be a pleasant object to look at. No one who has had experience in this delightful art would accept a mandrel which, whatever its other qualifications, appears to have been picked up at a country blacksmith's. Perhaps the reader will ask, Will not a common cheap mandrel do very well for a beginner, or to turn up all sorts of rough jobs? No doubt it will; but be sure of this, that when you are no longer a beginner but an adept, and when your jobs are no longer rough (that is, we may presume, *unworkmanlike and ill-made*), you will find yourself buying a new lathe of better quality, and the first will be seen to have been a throw-away of money, and to have absolutely *prevented* you by its clumsiness and want of truth from becoming a good workman. Get as good tools always as your pocket will allow, and then *take care of them*, and in the end your workshop will have cost you less than if you had, as so many have done, pursued a contrary course. Upon the supposition that a vast number of our readers are obliged to look a little to the question of cost, we think on the whole the following will be the

safest course to pursue in setting up a lathe:—Send to a good maker or dealer whose name is a guarantee of quality for a set of five-inch heads. You may pay rather (*very* little) less for a four-inch set, and still less for a three-inch; but though the latter may turn theoretically a piece of work of nearly six inches diameter, you would have but a three-inch pulley on the mandrel, or at most a four-inch one, and, the lathe being all in proportion, this work would be almost too much for it and for you. A three-inch would answer merely for light work, small engine cylinders and fly-wheels, and such like; but it may chance that you desire to turn now and then much larger pieces, requiring a lathe of larger dimensions, and for the general work of the amateur five inches from the lathe bed to the centre or axis of the mandrel is about the handiest size. Now, unless you wish to cut wheels with cogs, or practice ornamental turning, you will scarcely need a division plate on the pully (we shall describe this on a later page), as it will add £2 10s. or £3 to the cost. The mandrel-head with such division plate will cost £5 to £7, and without it, therefore, you ought to get it for £3 10s., which is about the price at Buck's, in Newgate-street. Now a good deal may be done with a mandrel-head alone without the second or back centre head. The latter, nevertheless, will have to be added, and it is better to get it at once. It will cost from £2 to £3, if well made. If, however, you cannot afford this, you may get instead of such (which is a *cylinder* head of the best construction) a cast-iron poppit with a plain centre screw through it for £1 or £1 5s., and it may do very well. You may therefore estimate the cost of a set of lathe heads alone at £5, and we repeat that they cannot be well made at a less price, though sometimes you may pick up one second-hand cheaper; but don't attempt this *unless you know well what good work is*, or unless you know that the person who previously had them would not have purchased an inferior set. Now, if you have done as directed, you have the *nucleus*, so to speak, of a good lathe, which will not disappoint you; there is, nevertheless, a good deal to be done before you can set it to work. It must be mounted on a lathe bed, and it must have fly-wheel and treadle. An iron bed is the best, nicely planed,

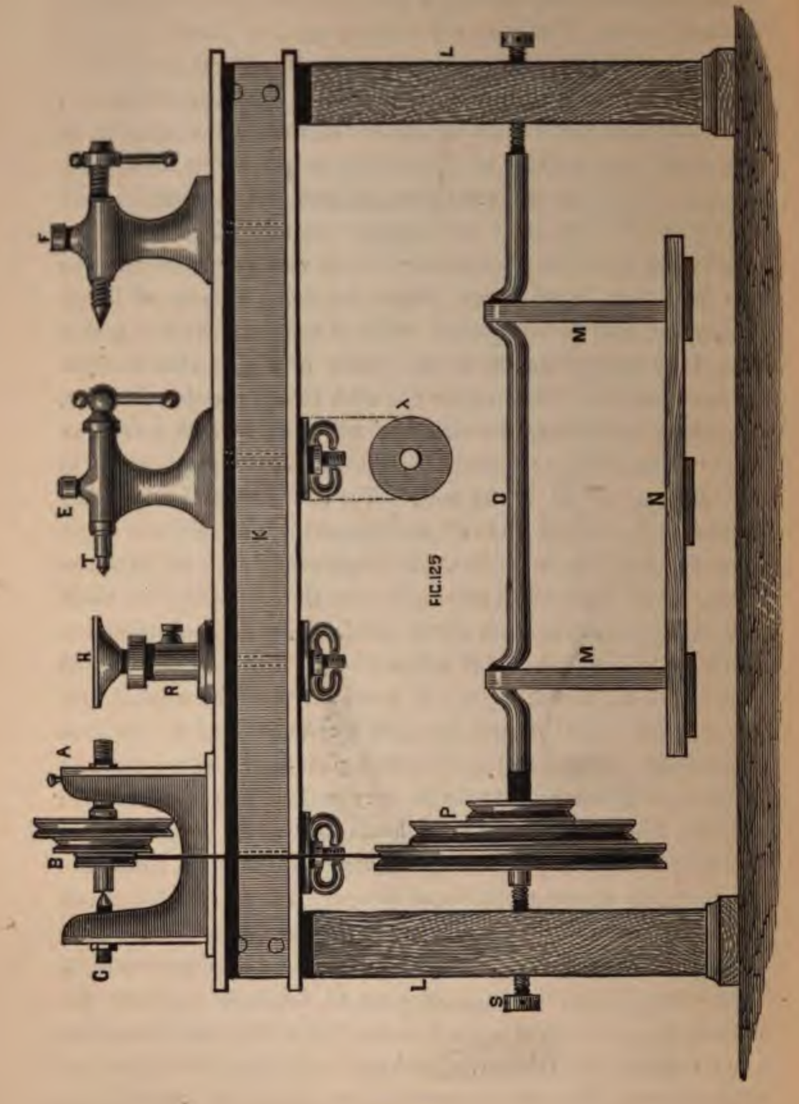
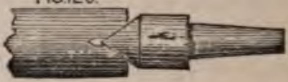


FIG. 125

and you may get such an one, four or five feet long, with iron standards and treadle at once to fit the heads, thereby adding £5 more to the cost, or you may set to work and substitute a wooden bed and frame, and put up with a very rough fly-wheel till you can do better. For, remember, although a well-rigged lathe looks better and runs lighter, yet, these lower fittings are of minor importance, and you may well supply them subsequently of more perfect design, using the more homely substitute for the present It is hardly necessary to give a drawing of a lathe, because the machine is well known to amateurs; but the above advice as to the purchase of a *good* mandrel-head is sound and practical, and worthy of attention. We have, nevertheless, given an illustration of a very useful kind of lathe with some additional apparatus often used therewith, Fig. 125. Now, supposing that the above price is still beyond the mark, it will be necessary to put up with a lathe of inferior workmanship; and, perhaps, in this case it may be as well to buy one complete, or, if not, the heads of the simplest make may be possibly obtained for £2 10s. to £3, and at this figure a lathe of four or even three inch centre is to be preferred. No doubt good work *has* been done with such a machine, but a little occasional trouble of screwing up, as the mandrel gets slack, and readjustment of parts, must be put up with. A triangle bar lathe of three or four inch centre, with flat rimmed pulley and plain fly-wheel underneath to take a strap, is the easiest to fit up, because the stand for the fly-wheel may be independent of the upper part, and any two inch plank will do for a bed, being handy and cheap. Lathes are made of this pattern quite good enough for models in brass and *small* metal work. The article to be turned has to be attached to the mandrel, so that when this is put into revolution by means of the fly-wheel and treadle underneath, a tool held firmly in contact with the work will cut it into a cylindrical form of more or less accuracy, according to the skill of the turner and the correctness with which the mandrel revolves in its bearings. Now, in order to attach the work thus to the mandrel, a set of chucks is necessary, the forms of which are various to suit work of all shapes and sizes. In the *first figure* of

this section, Fig. 125, A is the nose of the mandrel, to which the chucks are screwed ; B, the pulley, or cone of wood, or metal ; C, the tightening screw, or back centre point, against which the mandrel turns, the point of the screw entering a conical hole in the mandrel drilled to fit it. This screw and the mandrel being both, *in good lathes, of the best steel hardened*, the point wears but little even after many years' use, especially if it is so made as not to touch the bottom of the hole, which is usually the case—*always in best work.* Whenever, in fact, a revolving axle has to be thus supported by centre screws, the hole in its end should be of the form shown in section in Fig. 126, that is, it is to be drilled

FIG.126.



with a smaller drill at the bottom than at the upper part ; so that a conical point, such as a centre-bolt, will touch its sides but not abut against the bottom of it : thus, not only will the extreme end of such bolt be preserved in its sharply-pointed state, but the small cavity which thus exists beyond it will retain the oil applied to lubricate it, a most important desideratum in all such cases. Chucks are of wood or metal, and sometimes of both combined. Those of wood are easily made, it being only necessary to take a block of the required size, generally a slice of three inches or so in length, and of diameter suited to the work, cut from the end of a round piece of boxwood, ash, beech, or other available material. In one end a hole is bored rather smaller than the screw of the mandrel, upon which it is often screwed by force, thereby causing the mandrel to cut within the hole a screw similar to its own. This is at best a clumsy method. After the hole is bored, it should be cut inside with a *tap* of the same *pitch* or *thread* as the mandrel screw, upon which it can then be readily mounted. Such taps can be bought at tool shops to suit any work of this kind, whether metal or wood ; and a set of three for the former and one for the latter will be found very convenient. There is, however,

another method, to be hereafter explained, of cutting such a screw. Again referring to Fig. 125, two forms of back poppit are shown, E and F. In the first, the centre point advances and recedes on turning the screw without itself turning round. The point T, shown separately on Fig. 126, is also removable, and others can be substituted in place of it. This form of poppit is in all ways the best, especially when drilling in the lathe is practised. It is, however more costly than F, which has simply a pointed screw passing through it which can be clamped by the small bolt F. The extreme end, however, can, if preferred, be made removable, in which case it will be sufficiently serviceable, and may fairly take the place of the cylinder head E. These poppits, and likewise the hand-rest H, are secured by bolts screwed into them, at the lower end of which a thumb-nut works, as seen in the drawing. The bolt passes through the centre of the holding-down plates, of which the face of one is seen at X. The upper part of the rest, called a T, slides up and down in the upright socket R and can be fixed at any height by the screw at the side. There are long and short Tees—those for metal turning being made flat at the

FIG.127

FIG.128

top, as Fig. 127; those for wood generally have the form of Fig. 128, and should, as it were, *lean over*, so that the edge on which the tool rests, and along which it traverses as the work proceeds, can be placed as close as possible to the piece to be turned. If the latter is of great length, two rest sockets are used, and the long T requisite in such a case has two legs or tangs. M M are crank chains (a kind of flat broad chain specially made for this purpose); they pass over the cranks and round two rollers on the treadle, which are seen in Fig. 129. This is the best way to connect the treadle with the crank; as the movement will be smooth and easy, a mere hook will, however, answer the purpose. The pointed screws S S, of hard steel, support the axle, the holes in

the latter being drilled as before shown in Fig. 126. Another superior method is to use friction rollers, Fig. 130, where *a a* represent two small brass wheels, about 3in. across the face, and half an inch broad, their edges at least turned up bright. These are mounted on their pivots so as to overlap a little, and the ends of the lathe axle are simply laid upon them as in the figure, its weight keeping up a constant rolling contact as it revolves. This is by far preferable to the sustaining screws, rendering the work of the legs almost nominal. The ends of the axle must be turned with a shoulder to prevent end motion; and it is convenient to carry it *through* the standards so as to be able to afford, *outside* the latter, an extra pulley for connection with any special shaft or overhead motion. In many lathes the axle is not cranked but straight, a crank being then keyed on at each end outside the

FIG. 129.

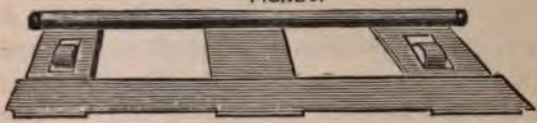
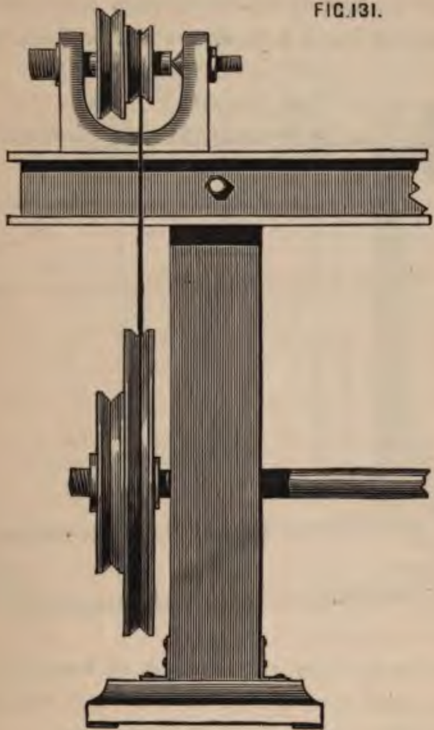


FIG. 130

standards to take the crank chains. To carry this, which is a neat plan, into effect, it is necessary to let the ends of the back bar of the treadle pass through bearings in the feet of the standards, and to attach outside the latter arms to receive the crank chain pulleys. There is no practical difficulty in this, and the straight axle is more desirable, besides the advantage afforded of removing the crank chains out of the way of the legs. In respect of this last point, moreover, it would be better if possible to get the fly-wheel also outside the standards, or, at any rate, to move it back so as not to project at all in front of the lathe. In some old French lathes, the fly-wheel was placed overhead upon a strong pillar carried up by the left-hand standard, or forming an extension of the latter; this gives a clumsy *top-heavy* look to the lathe; otherwise the purpose is sufficiently answered of moving the large wheel out of the way, and with it the lathe cord, so that (as in a machine lathe) the whole bed is clear from end to end. There is no reason why the crank and fly-wheel should occupy the place usually assigned to them, as

they might be advantageously mounted on a separate stand, independently of that which supports the bed of the lathe, provided the treadle be still brought into a convenient position. It is only for the sake of handiness, in other respects, that the crank axle is placed below the bed, and that the lathe may be complete in one frame. If, for instance, the fly-wheel were outside, as Fig. 131, and the

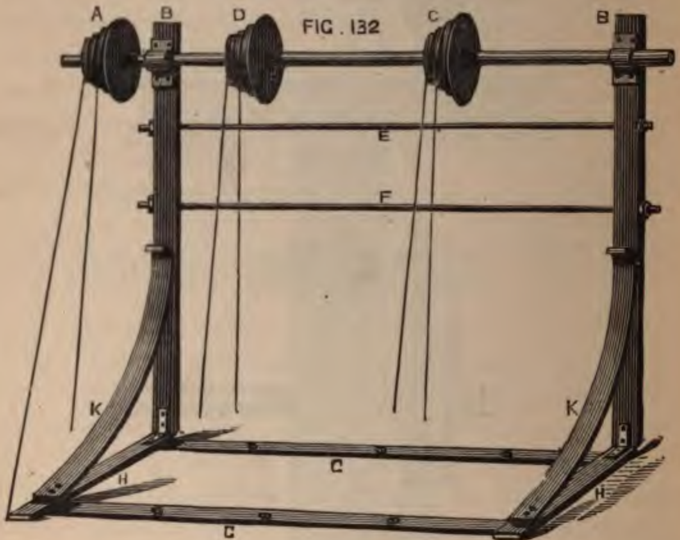
FIG.131.



mandrel turned round as shown, on special occasions it would be possible to turn a small table, or any article much larger than could otherwise be managed, but the bed must slightly overlap the standards to enable the poppit to be secured and also the rest; the latter however might be contrived somewhat differently for such exceptional cases. There are one or two drawbacks never-

theless to the position of the wheel here shown. In the first place, though the wheel and cord are out of the way, the standard now takes up a similar position as regards the turner, and the only really practical method of overcoming all drawbacks is to carry the lathe-cord from the wheel outside the standards to a shaft overhead and thence down again to the mandrel. The additional friction of the shaft through its bearings has indeed to be overcome; but if friction wheels are used on the crank axle, and the parts are all well made with hardened steel screws and well-drilled axles, the

FIG. 132



advantages of such a plan will be great, as the mandrel-head can be placed anywhere upon the lathe bed or faced either way as most convenient, and the overhead motion answers for purposes of screw-cutting and ornamented work when required. An illustration of such an arrangement is consequently given in this place, which may, of course, be nevertheless modified if desired. The whole apparatus, too, may be simply beyond the bed instead of overhead, nd thus can be attached to the frame of the lathe itself. This is the construction represented in Fig 132. B B are uprights of flat

iron bar, made into a frame by cross stays E F, and hinged at the bottom to a frame G G H H, the latter being secured to the bed or backboard of the lathe. K K are curved steel springs, tending to cause the upper frame to lean backwards, thus keeping up the tension of the lathe cords. A D C are three pulleys or cones, of which A is fixed to take the cord from the fly-wheel of the lathe. D and C should be free to slide upon the bar, on and with which all the pulleys revolve, and may thus be put in any position upon the same, and clamped by a screw when in place. The distance B B should be that of the length of the lathe-bed, the height about two feet, and the whole should be carefully and strongly put together. For special purposes the pulleys may at any time be replaced by others of a larger size. It is just possible that the cord from the right-hand pulley may come in the way of the work when used to convey motion to the screw of the slide rest for self-acting turning and screw-cutting, but this will rarely happen. It may be prevented by having long slots in the part H H, so that the frame can be bodily shifted further off or nearer the lathe-bed, and it would then be clamped by large-headed bolts and nuts passing through the backboard. It is not necessary to detail other modes of arranging the overhead apparatus of lathes, as they vary according to the tastes of the makers. All that is necessary, is to have a method of keeping the cords tight, either by balance weights or springs. The pulley C is also replaced by some makers by a long roller, so that the cord may be placed at any point over the work to be turned, without the necessity of shifting the pulley. It is a good plan, but sometimes the cord may slip on the smooth surface of such roller, hence it is also not unfrequently grooved.

A great deal of the ease with which turning is carried on depends upon the chucks used, for in many cases it is a work of time and trouble to arrange a plan by which the piece to be turned can be satisfactorily secured to the mandrel. Wooden chucks are of necessity often used, as already stated, being simply blocks of the required size screwed to the mandrel and afterwards hollowed out to receive the work. These have one advantage, namely, the

facility with which they are made and altered; and, even when a lathe is fitted with an assortment of metal chucks, those of wood cannot be dispensed with, but they should not be wholly depended upon where great accuracy is required, and, after much consideration, the writer recommends two chucks, Figs. 133 and 134, to be added to the usual list, of which a sketch, with description, will be given. It is true both are somewhat expensive, but their use is unquestionable, and it is very difficult to wholly dispense with them. A detailed

FIG.133

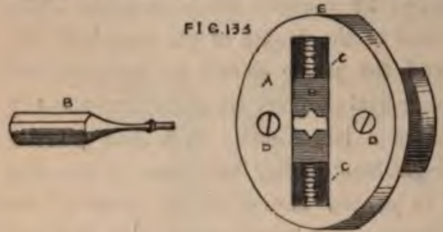


FIG 135

FIC 134

description is given in a later page. Of metal chucks *indispensably* necessary are, first, the carrier, or dog chuck, for turning bars of metal, Fig. 135, A B C. The body, or main part, of course screws to the mandrel. Through it is cut a square or rectangular slot, into which is passed the leg of the L-shaped driver, and this is clamped by a screw seen at the side. Into the face of the chuck is fitted a centre point of hardened steel. A^1 is the carrier, of which there should be several kept for various sizes of work. This is slipped on the end of the bar to be turned and secured by its screw. The tail of this driver is generally solid, but it is better to have it made

with a fork, into which the driver will pass. In Fig. 136, a bar is seen fixed ready for work. When thus made, the carrier cannot move from the L-shaped driver. Sometimes, this chuck is differently constructed. The carrier plate has a slot to receive a pin which passes through it, and is held by a nut at the back. The

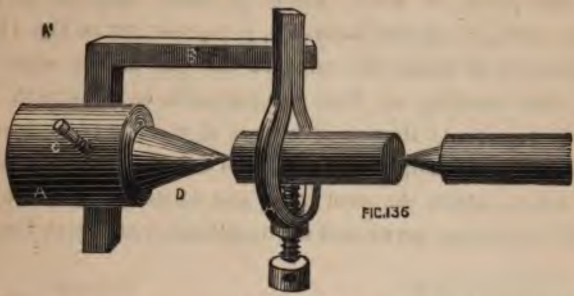


FIG.136

centre point is either screwed into the face of the plate, or dropped into a conical hole, being then formed like Fig. 126, which also serves to represent the end of the bar properly drilled; and it may be observed that the holes or centres made should not be obliterated when the work is finished, but retained, so that if necessary for repair or otherwise, such pieces can be returned to the lathe at any future time with the certainty that they will run truly as at first. A, B, and C, Fig. 137 represent the fork or

FIG.137

prong chuck, commonly used for bars of wood. The socket C, which is the body of this chuck, has an internal screw and attaches to the mandrel, and opposite to this another hole, which should be circular or cylindrical, into which not only the prong represented will fit, but also drills, and even occasionally pieces of stout wire or small rod, to be turned up for screws. Such drills are frequently made with a square shank, and the hole in this chuck is very generally made square; but this is not a good plan,

as their centrality cannot be so well secured. It is much better to make the shanks round, merely flattening them at one side to take the pressure of the end of the clamping screw, which will prevent them from turning round in the chuck. The fork and other fittings are also thus flattened. Another form of chuck for pieces of wood, which in many respects is better than the prong chuck just described, is represented in Fig. 138, D. This is wholly of metal, the cross on the face of the same being of thin steel standing up from one-sixteenth to one-eighth of an inch. D represents the end of a piece of wood to be mounted on this chuck; and it will be seen that two saw cuts are made at right angles which admit the steel cross, and when the back centre is screwed up nothing can exceed the steadiness with which the work

FIG 138

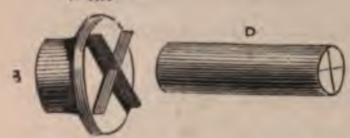
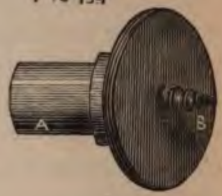


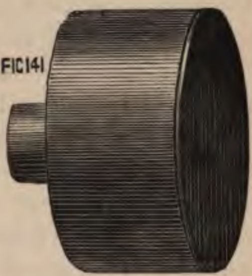
FIG 139



is held. It cannot possibly slip or get out of centre, whereas, when the prong is used, such mishaps are not unfrequent, especially with learners, who have a wonderful knack of catching the point of a tool in their work. This chuck may be either made with a flattened tang, like the prong, so as to fit the same socket, or independent, so as itself to screw to the mandrel; rods of metal may be similarly mounted, but the carrier chuck is most generally used for this purpose; in cases, however, where the carrier would be in the way this cross chuck may become a useful substitute. Fig. 139 is the taper screw, used to mount short pieces requiring to be bored or otherwise turned at the end, and which consequently cannot be there supported by the point of the back centre. The latter may, nevertheless, be advantageously applied during the operation of roughing down and turning the cylindrical surface of such pieces. It can then be removed for the subsequent processes. Fig. 140 is

a flat disc of metal with five short steel points projecting from its face. This is very useful to support thin pieces of wood not requiring to be turned on both faces. It is a *soft* wood chuck much used in making platters for bread and such like work. The back centre must generally be used to press the work firmly against the points. A careful hand, however, will find no difficulty in removing the centre point for the finishing touch whereby its mark may be obliterated. The *face plate* for wood is merely a disc like the last without the points, but with several holes drilled in it countersunk at the back. The piece to be turned is held by ordinary wood screws of various lengths according to the thickness of the piece, care being taken that they are not so long as to hazard penetrating the wood completely when the latter shall nave been


FIG. 140

FIG. 141


turned, else the chisel will, of course, be spoiled. It is a common plan to have several such chucks, of different sizes, which can be attached to wooden blocks for the purpose of making the latter into cup chucks. When these are done with, others may be substituted. Thus the boring and tapping of the wooden chuck itself is no longer required, and pieces of wood of almost any shape, and not thick enough to allow of being themselves bored and screwed to the mandrel, can be utilised. The above chucks are for the most part suitable only to soft wood. Box may, indeed, be fixed on the taper screw, Fig. 139, a hole being first bored in it rather smaller than the base of the screw; but the latter, if long and able to be used with the back centre, is better mounted on the cross chuck, Fig. 138; and if short, or requiring to be bored or faced, it is more conveniently held in a cup chuck, Fig. 141, either of

metal or wood, of which many sizes will have to be prepared. We now come to the two chucks represented in Figs. 133, 134. These are of very similar construction, but Fig. 134 is much larger than the other. The latter is called a self-centering, jaw, or scroll chuck. There are several ways of making it; but the one represented has simply two curved jaws, which, upon turning the screw which passes through a boss beneath each, below the level of the surface, advance simultaneously towards each other, both being always equidistant from the centre. Thus any cylindrical piece grasped between them when the chuck is on the mandrel will *run true*. Finished work may thus at any time be replaced on the lathe with certainty of being mounted concentrically with the mandrel. The screw is merely made half with a right and half with a left hand thread of equal pitch. This screw is prevented by collars from itself moving endwise, it therefore of necessity draws together the jaws which below the surface plate become *nuts* to the screw. The jaws represented should be removable at pleasure, and others of less diameter, or of angular form, should be made to screw into the nuts above mentioned. Fig. 133 is made in a similar way, but is much smaller. It is called a *die* chuck and must be strongly made. The dies are only made to hold small pieces of metal from $\frac{1}{8}$in. to $\frac{3}{8}$in. or thereabouts in diameter. It is very convenient for turning small screws, and similar work, which have to be turned and tapped without removing them from the lathe; they can then be reversed if the threads are protected by a fold of leather or lead, and the heads turned up and polished. These last chucks are so advantageous that the writer deems them almost a necessary part of the lathe, although from their cost they often have to be dispensed with. The first is, to a great extent, a *universal* chuck—for instance, it will serve for the following and many other purposes:—A piece of wood sawn from the end of a stock can be at once centrally placed, and securely gripped, and thus may be immediately bored, faced, or turned for use as a cup chuck, or, if desired, may be turned and finished as a box or other desired specimen. A rough brass or iron casting may be similarly mounted without any preparation or loss of time. A *ring* of metal or wood

can be slipped *over* the jaws (which are then caused to *recede* from each other), and can be turned on the outside. When thus rendered true, it can be removed and placed *within* the jaws and can thus be internally turned up and faced. Metal cup chucks in the rough casting can be first held face downward, so that they can be bored and tapped to fit the mandrel, then transferred to the latter to be finished without and within. Boxes and other work, previously turned and laid aside, can be, by the use of this chuck, correctly remounted for purposes of ornamentation. These few instances of the use of the self-centering chuck are adduced to show that to the amateur it is at least *worth its cost.* It should be made as light as consistent with strength and the uses for which it is designed. The die chuck is often replaced by a cup chuck, the metal of which is thick enough to give firm support to six or eight screws tapped into it, the points or ends of which converge to the axis in two planes. The screws are therefore placed *radially*—three near the mouth of the chuck, and three nearer to its base. If the die chuck is omitted, this one must take its place; but the metal should be so thick that the heads of the screws project as little as possible, even when drawn out to the utmost, so that their inner ends are flush with the inner surface of the chuck. This is managed by tapping them into place, and then adding a thick ring, with holes bored round it, to receive the heads of the screws as they are withdrawn. In this way, as the latter seldom project beyond this ring, the knuckles are protected from unpleasant knocks and excoriations. Small rings of wood or metal require a chuck which is generally merely a conical spindle, upon which they can be lightly driven. Sometimes, instead of being made conical, such spindle is the same size from end to end, screwed, and furnished with a nut, or a couple of nuts, between which any ring or disc can be clamped. A different-sized spindle, however, becomes necessary in this case for rings of large or small internal diameter. To overcome this necessity, the following is a good and valuable plan:—Make a spindle, of any standard size preferred, according to the *probable* sizes of rings, washers, &c., likely

to be needed; or make a set of three such spindles of assorted sizes. Near the left-hand end affix a flange, and from this to the right-hand end cut a screw thread. Make a round nut to suit this screw the same size as the flange. Now, if the internal diameter of the ring to be turned is the same as that of the screw, it may evidently be merely slipped on it as far as the flange and held tightly by the nut. But, if the ring does not thus fit either of your set of mandrels, drill a hole through a cylinder of wood, which *will* thus fit upon the screw, and turn down this sleeve or socket until the ring driven on will fit it tightly. This cylinder of wood must, in *length*, be rather less than the *width* of the ring to be turned, so that the latter will be held tightly between the flange and nut when the latter is screwed up against it. A similar arrangement will suffice to turn up small cylinders, which should, however, be first bored and then slipped on such a mandrel as that described, when it may be finished on the outside with certainty of the internal and external surfaces being concentric. Another kind of mandrel, wholly of metal, will hold tubes of various internal diameters without any such wooden sleeve as described. Let the screw be made as before; but the fixed flange must be made conical, the small end pointing to the right hand. The nut is also a similar cone, but pointing towards the other. The tube to be turned will thus be held *between* and partly *upon* the two cones, according to its diameter, the screw no longer serving in any degree as a support to the work, but merely affording the means of bringing the cones near each other. It is a good plan to run a milling tool over the surface of these cones after they are turned, to assist their internal grasp of anything thus turned upon them. There are few articles that cannot be turned upon one or the other of the above chucks. The face plate for metal is similar to that described for wood, with holes for screws; but the former is made with slots as well as holes, and various clamps of iron are fitted for use with it, to hold down upon its face any object to be turned, such as wheels and metal discs. The self-centering chuck, however, with two jaws, will also hold such articles securely; and there are no clamps and bolts to come in the way of the tools.

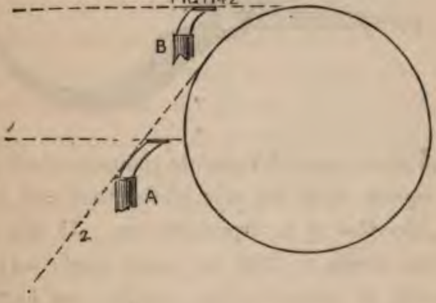
TURNING OF WOOD.

The principle of turning is simple enough, as it merely consists inapplying the edge of a suitable tool held firmly upon a support in contact with a more or less cylindrical piece of wood or metal suspended between two points and in a state of rapid revolution, when a shaving or shavings will be detached and the work rendered true and even. The *practice* is quite another matter, and cannot be learned without time and attention; but, although no book can adequately teach the art, there are certain rules of manipulation which can and must be thus put before the tyro, and which will be of the greatest possible assistance. For instance, a wrong tool, or a right one wrongly held, or badly sharpened, of necessity will either make bad work or none at all; and the object of the present work is to prevent disappointment and the disgust which arises from a failure in this delightful art, to say nothing of additional pecuniary loss in the destruction of tools and materials more or less costly. For turning the soft woods, alder, willow, beech and birch, mahogany, sycamore, and similar material, few tools are needed—the gouge and chisel alone sufficing for most operations. Three sizes, however, of each of these should be procured. They must be well ground with long bevels, and then sharpened upon the oil-stone, as directed when speaking of carpenters' tools; and, once for all, let the *rule without one exception* be noted, that, unless the tools are kept sharp and keen as possible, only the most imperfect and bad work can be done, though the lathe and its appliances may be of the best. As an example of the most simple work, let it be required to turn a tool handle. Take a piece of beech or ash, about eight inches in length, and of a diameter rather greater than the proposed handle at its largest part, set it upright in a vice, or hold it thus in any other way, and make two slight saw-cuts, as in the Fig. 138, D. Screw on the mandrel the cross chuck and thus mount the work in the lathe, bringing up the movable poppit and causing its point to enter slightly

the end of the wood. Do not screw up tight until you have tried by a turn or two of the mandrel whether the wood runs pretty accurately. If so, tighten up; if not, shift it as required. Put a drop of oil on the point of the back centre, and drop some through the oil hole of the fixed poppit to lubricate the mandrel and collar. Do the same at the other end of the mandrel, at the bearings of crank shaft and treadle-crank hook or chains. Take that T of the rest which will reach from end to end of the piece to be turned, or nearly so, and let the top of the T be on a level with the axis or centre line of the work and mandrel, or a little below it, and set the rest so near that the work as it revolves will just clear it. Take a medium-sized gouge, and set the lathe in motion, not too rapid at first; but when you can turn readily after practice, the faster the better for soft woods. Lay the back or rounded part of the gouge upon the rest, holding the handle in the right hand with the thumb upwards, and grasp the blade near the rest with the left, the little finger being next the work; the slope or angular position should be such as to bring the edge at a tangent to the work, in which position it will cut, whereas, if held horizontally, it would scrape, and the first touch of the wood would carry off the edge and probably break out a handsome (?) notch as well. The handle of the tool will thus be low down and is to retain this position. If, however, too little of a cut seems to be taken, raise the handle until the tool appears to do duty fairly. As, however, it is rather desired to set the learner right upon principle, a few words in way of explanation may not be amiss. It is not that the tool need necessarily touch the wood at any particular point, nor that it requires to be held with the handle sloping downwards; but certain conditions have to be fulfilled to make it cut properly. In Fig. 142, if the rest is at A as directed, the tool can be held at 2, at a tangent; at 1, at right-angles to the axis of the wood, or at any intermediate position. At 1 it will scrape, at 2 it will cut well, at any intermediate position it will *tend* to do one or the other. Now let the rest be raised level with the top of the work, and *the right position for the tool is horizontal,* which before was the worst in which it could

be placed. Hence we obtain the rule for cutting tools of this class. *The bevel which is next the work must make as small an angle with the work as possible :* in other words, the under surface of the tool must lie as flat upon the work as it can be made to do without rubbing. Thus it will be evident that the bevel of the tool should also be flat or concave, never convex, or the angle must be unduly increased to cause the edge to cut. It will be found hereafter, in considering the action of metal-turning tools, how generally essential the observance of this law is. Having placed the tool properly, the tendency of the rough piece of wood will be to jerk it off the rest towards the operator, and this is to be resisted by holding the tool

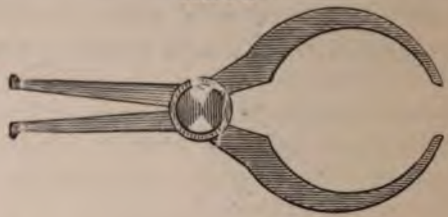
FIG. 142



firmly ; nevertheless, it is almost certain to be thus caused to jump from the work a little at first until the rougher projections have been cut away. It will then run more evenly, and less difficulty will be found in keeping up the tangential position of the tool. The latter has, of course, to be moved along the rest as the work proceeds. Most workmen who have to copy any particular pattern, as, for instance, a tool handle, take the size with the callipers (Fig. 143) of the largest part, and reduce the wood to that size at the right spot. They then take the measurement of the recess or small part next to it, and cut down the material to that gauge. Then they are enabled to cut boldly and evenly from one to the other. This is a good plan, the result of practical experience, and should always be followed where possible. In turning a *cylindrical* piece to a given size, it is far easier to turn

down two or three places first of all to gauge, and then to cut away quickly and boldly the intervening surplus substance, than to keep on cutting and testing with the callipers (Fig. 143) as the work proceeds. Supposing the gouge to have reduced the piece to the required form the chisel must be taken in hand to finish it smoothly from end to end. This tool is difficult to use at first; but the chief *risk* is of the *upper* angle catching in the work. The tool should lie as flat as possible; but that upper corner must be kept clear of the work. The

FIG. 143.



tool, is ground at an angle different to the carpenter's chisel. The edge is not square with the side of the tool, and it has also a double bevel, like that of a carpenter's axe. It can thus be laid either side downwards, so that the acute angle may be above or below the work, at pleasure; but, whether you have this or the obtuse one upwards, it must, as aforesaid, be kept clear.

There will probably be found a slight difficulty at first in turning the deeper hollows of tool handles and such like in making the two downhill cuts meet at the bottom without leaving a ridge or rough place. A little practice will overcome this; and although at first a rub with sandpaper at the junction of the cuts may be necessary, this and all similar abrasive material should be discarded as much as possible, as the best surface that can be given to turned work is that produced by the clean cut of a *sharp* chisel. Some kinds of work, especially that done by the gouge, and surface work as the face of a bread platter, may require to be finished by the application of fine sandpaper; but these should be considered exceptional cases, and the turner should always strive to finish with the cutting tools alone. Tool handles require a ferule to prevent the wood from splitting when the tang of the

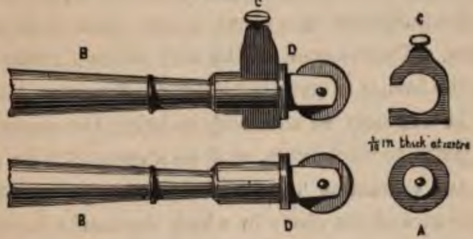
tool is inserted. The place for this ferule should be turned down before the final cut is given, or even before the handle is fully shaped. The ferule (cut off the end of an iron or brass tube) may then be put in place, fitting tightly, and the handle returned to the lathe to be completed, after which the ferule may be turned up with a graver or other suitable tool, or partially finished up with a file, which in many cases will be sufficient for the purpose. An old gun barrel will make good iron ferules, but they can also be purchased by the lb. in London, where they are cut off the tube as required by a circular saw. The amateur is strongly advised to do as much turning as possible on the softer woods with gouge and chisel alone, as these are the most useful tools of the general turner, requiring far more skill and practice than those used upon hard wood. The latter rather scrape than cut, and their use is more readily acquired in consequence. The gouge is a famous tool when used as it ought to be : it will leave the work quite smooth, and will square off the ends of cylinders, and face up flat surfaces in a wonderfully ready manner ; but a little extra practice is requsite to produce these effects. In both the latter cases, the back, and therefore the bevel of the tool, rests flat against the work, the edge being just allowed to cut and guarded carefully from the tendency to draw itself in deeper. A great deal of flat work or facing is done in this way, the rest being placed as near as possible to the work ; but there are other tools used for this purpose, and which some think effect it more readily. They are called "broads" or "flat tools," and will be described presently. In cutting off the ends of cylindrical pieces with the chisel, care must be taken to hold it either perpendicularly to the work, and to use the sharpest point, or to incline the upper angle rather away from the work, or the part of the edge not in cut will be drawn in as the piece revolves, and trace a screw upon its surfaces, defacing what was already finished and otherwise damaging it. As a test of the learner's capability of using the gouge and chisel, he may try to make a round ruler of mahogany ; if he can effect this without the use of sandpaper, he will find little difficulty to contend with in his future work upon the lathe. There is a great

deal of twisted work used in the present day, such as was in fashion in the reign of Elizabeth of questionable memory. It is not very difficult of execution by hand tools alone, and indeed by far the greater quantity of such work is thus accomplished; although it is so regular it appears to have been effected by a machine. On the right-hand side of Worship-street, going east towards Bishopsgate, is a small turner's shop, where no doubt a few shillings would obtain practical information upon the subject, for an immense quantity of twisted work of various patterns is done there, and well done too. It is in some degree, like other turned work, a question of practice; but the plan to be pursued is as follows:—Turn a cylinder with its mouldings at the ends, or, if preferred, let the piece be turned slightly conical instead of cylindrical. This must now be marked for the twists, and on the whole, especially if a number are to be turned precisely alike, a knife may be used held at the necessary angle in contact with the piece, which will indent a screw thread, or spiral, upon its surface. There is a way of marking it by ruling longitudinal lines crossed by others drawn round the piece, and the spiral is traced through the intersections of these lines; but the process is tedious, and the knife edge will be found on trial easy and convenient. As an experiment, to show how the thing is to be done, set the lathe in motion and let the edge of a knife held loosely in the hand rest upon the work. It will be carried forward if held with its point slightly directed towards the mandrel while its blade is held perpendicularly to the surface, and it will be noticed at once that the more sloping the knife is held, the coarser will be the screw or twist. Hence, if a small block of wood is taken two or three inches in length, and a saw cut is made across it at an angle to receive a knife blade, so long as the edge of this block rests truly against the work, the blade of the knife will remain at the same angle and will trace a true and even spiral upon the revolving piece of work. There is no more easy method of effecting such tracing of a screw thread; and it is only necessary to have a few blocks with saw cuts at different angles, to enable the turner to give as few or as many twists in a given length as he pleases. This

plan has indeed been modified to produce an instrument for tracing screws on wood or metal, as well as for cutting spirals, and as it may be considered a useful arrangement, it is introduced here, from a communication to the " English Mechanic."

Fig. 144 represents a revolving cutter in a handle such as is used for putting a milled edge to screw heads, but without teeth or other pattern. This, applied to the surface of a revolving cylinder, would, if held so that the cutter is perpendicular to the axis of the work, merely trace a ring round the piece. Held at an angle so as to lean towards

FIG. 144.



the mandrel, it will tend to creep along in that direction, and to trace a spiral. To enable the turner to place the cutter thus, at any given angle so as to trace a close or a coarser thread, the small cast-iron block is added. The shank of the tool is turned in one place to fit the large hole in this piece, and there is a mark, or, if desired, several marks, by which any angle can be readily obtained, so as to repeat any spiral previously cut or to originate a new one. The under part of the block is planed to slide evenly upon the edge of the ordinary rest, and it might perhaps be better to form it into a rebate, or cut a groove to make it move upon the rest more surely in a straight line. The tool being placed as desired, is clamped with a set screw, and will be found to work extremely well. After having marked one thread of the spiral, a second mark must be made in a similar way to determine the thickness of the thread or ridge which is to be left, and the intermediate parts which will remain between any two of such double lines are to be cut away carefully with a very sharp gouge. Lest the thread be intrenched

upon and chipped, however, it is better to take a fine tenon saw, and following the lines, cut a little way into the work as a commencement; the gouge can then be used with greater certainty and freedom. These directions pertain to a single thread only, but generally one or two others may with advantage be made between the ridges of the first. For this purpose it is necessary to divide the *end* of the cylinder by marks, in pencil or otherwise, to determine the commencement of each spiral. If the mandrel pulley has a division plate upon it, this may of course be done without difficulty; if not, as only a very few divisions are necessary, no great difficulty will be experienced in marking its face with a pair of compasses round the circumference of a circle traced upon it for the purpose as it revolves. Twelve such marks will suffice for this work, as it will enable the turner to arrange two, three, four, six, &c., threads at pleasure. It will only be necessary to bring the required mark to some fixed point to start with, such as a pointed wire driven into the poppit and extending to the face of the pulley exactly upon the circumference of the circle in which the marks have been made. To cut out what is to be removed, the pulley must at first be pulled round by hand; but when the first cuts have been thus taken, it will not be difficult to use the gouge while the mandrel is revolving, as usual, by means of the treadle. It is necessary, nevertheless, to take care not to overstep the grooves in this operation, and a coarse round rasp may be used to facilitate the work, to be succeeded by glass-cloth or sandpaper; or a kind of plane, with a round-edged cutting iron, may be run along between the threads until ready for the sandpaper, which in this work, especially if of deal, can hardly be avoided. If the threads are to be rounded, instead of, or in addition to, the hollows, this may be also effected by the rasp, although a plane with a hollow iron may be used for the same purpose. The rasp is the more usual tool for this work We have referred to a tool called a *broad* for levelling the flat surface of lathe work, such as large platters, and similar pieces, which are not easy to finish with the chisel and gouge. These are something like an arm-rest being a broad bar of steel turned up at the extremity for a short distance and sharpened. The pattern is, in

fact, almost identical with the hook tool for iron. Figs. 145 and 146 represent—the first, a broad; the second, a soft-wood internal gouge, or hook tool, which, in the hands of those who turn much in this material, is extensively used to hollow out boxes and such like work. Both these tools must be so held as to lay the bevel (which is on the outside, almost flat against the surface of the work). They are difficult tools in the hands of the novice, from their tendency to draw deeper into cut, and thus either hitch and spoil the work, or else to be wrenched from the turner's hand. As the broad is quickly ground away by frequent sharpening which destroys the hook, it may be modified as follows:—Fig. 147

FIG. 145

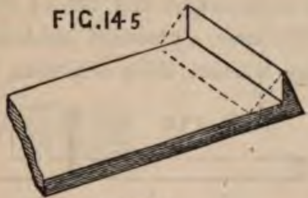


FIG. 146

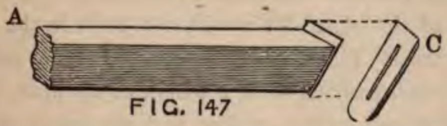


FIG. 147

shows a square bar of metal A, at the extremity of which is affixed a loose plate, shown separately at C, which is the cutter, and is ground at one or both ends to a bevel as in the ordinary tool; this plate is fixed by a screw, the head of which is countersunk, and lies in the slot of the cutter. Thus, the latter can be placed with the smallest amount of projection possible above the face of the bar, which is also ground off level at the requisite angle, about 45° from the perpendicular, the iron is sub

sequently sharpened to about 35°, which will give the same angle with the surface of the work when in use as a plane iron of the usual pitch. The same effect, so far as the drawing in of the tool is concerned, may be produced by placing within the ordinary broad a piece of brass or hard wood of square or triangular section, as dotted in Fig. 145, the same being secured by a screw ; but as the grinding lowers the cutting part, this block must be likewise reduced. With a rectangular piece slightly relieved on the outside so as to allow the piece almost to touch the edge at the top, but with more space below, as Fig. 148, which is a section, a kind of plane may be made which cannot possibly dig into the work, while the shavings will escape right and left at the lower part of the block of wood. Of course, a practised hand, such as a Tunbridge turner, can manage without these additions, but the broad and

FIG. 148

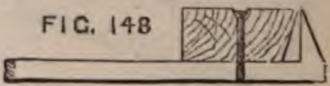
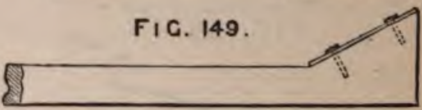


FIG. 149.



hook tools for soft wood are sure to dig in if great care is not taken. Another modification of planer for surfacing soft wood is shown in Fig. 149, in which the iron is arranged on the top of the tool instead of the edge. This will not hitch in the work, and is very easy to make. When the gouge is used it must not be brought into a horizontal position with the hollow upwards, but laid with the bevel flat against the surface, and the hollow side outwards. The chisel must lie in a similar position, the lower angle chiefly coming into use, when the shaving will curl off in a cupped form. This use of the chisel is also difficult from the before-named reasons; and the gouge is not only safer, but will put almost as good a finish to the surface. Hollowed work, such as boxes, bowls, and similar articles, if of soft wood, require either the gouge or the hook tools, Fig 146 The back poppit is not required, as the work is either held in a cup chuck or screwed direct to the mandrel, or affixed to

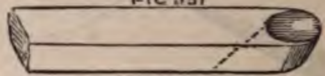
the taper screw chuck. If desired, however, the back centre may be brought against the piece until the roughest parts of the cylindrical surface have been reduced, as the removal of these may possibly even break the taper screw, and in any case is liable to loosen the work upon it. The right-hand end may also be squared up nearly to the centre by the gouge applied as directed, the small piece remaining being removed after the back poppet has been withdrawn. Suppose it is desired to turn a box, the usual method is as follows:— Take a piece of thoroughly dry stuff—willow, sycamore, birch, or, still better, pear-tree (which will answer excellently and is also a soft wood)—cut off a short piece, rather more than sufficient, as you have to reckon upon the length of the taper screw and must allow for waste in squaring up the ends and cutting off the cover and

FIG. 150.

so forth; bore a hole in the centre of one end, and screw it to the chuck before-named, which is specially intended for this work; take care to cut it off truly square, and do not make the hole too large, as it should at once run tolerably true and be firm upon the chuck. Having by the gouge and chisel made a cylinder, and turned the outer end smooth and true, the rest is to be turned round so as to lie parallel with the end of the wood, and the extremity is to be hollowed out to a small depth for the cover. This can be done as described with the hook-tool or the gouge: the latter, however, is to be held as for surfacing (Fig. 150) and the cutting edge is generally placed beyond the centre, in which case the rest need not be turned round. A few trials will do more than any written description; and if it is remembered to keep the bevel at the back of the tool almost flat against the surface, no difficulty should be

experienced. A small flat tool, or broad, or even a carpenter's chisel, will finish the work; but sandpaper may possibly be necessary. After the cover is finished to the depth required, proceed to cut it off with a soft-wood parting tool, taking care to leave enough thickness in the top of the cover. This tool is a very narrow chisel with two bevels, and for soft wood is notched at the point so as to be in effect two saw teeth. Now hollow out the box, cut the recess for the cover, taking care to make it true and not the least conical; fit the cover tightly on, and finish the outside of both together; cut off the box, and your work is done. The most probable fault will be a conical neck or flange on which the cover is to rest, and the same or similar fault in the internal form of the box. These faults are therefore to be chiefly guarded against. After the work is done and finished as smoothly as possible, it may be either varnished or polished as directed in the chapter on that subject. There is no occasion to make an ordinary flat cover and cylindrical box; and it is well thus early to try the hand at designing something of a more elegant shape. Most of the boxes for scent bottles sold by druggists

FIG. 151



are made of pear-tree, and this wood will moreover take a very good screw thread. This, however, being a process that cannot be attempted until the use of the gouge and chisel and other tools for plain work is acquired, will not be treated of in this place.

Difficult as it is to acquire the use of the hook tools or inside tools for soft wood, they execute their work so rapidly, compared with the gouge, that it is well worth the turner's while to persevere in this matter. The great aim must be to prevent the tool from drawing too deep into cut. The bevel should be laid first of all quite flat against the work, so as to prevent the edge from cutting; and then the tool should be tilted just sufficiently to remove a fine shaving. A modification of hook tool is a bar of steel bevelled off at the end and rounded, through which a hole is drilled diagonally, Fig. 151. This, so long as it lasts, is a tolerably good and safe tool, as it cannot cut much too deeply, and the

edge is such as can be applied to the sides and bottom of any internal work. Soft wood turning is not much followed by the amateur, whose object is generally to produce specimens worthy of the drawing-room in the hard woods and ivory; but as the present papers are rather addressed to those of engineering tendencies, who have to make models or patterns in deal or mahogany, and many of whom do not aspire to costly lathes and apparatus, the remarks on soft wood turning have been more extended than they would otherwise have been. As regards, moreover, the *useful*, there is far more to be done in the soft woods than in those which are more expensive; and if the use of the soft wood tools is once acquired, there will be no difficulty in executing work in the choicer materials.

TURNING HARD WOODS, IVORY, AND BONE.

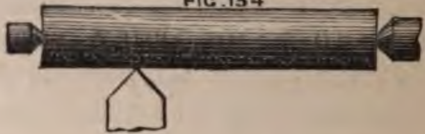
The tools for this work are made upon a different principle, and can hardly be said to cut, although much depends upon the way in

FIGS. 52 & 53.

which they are applied. They are of all possible shapes, as will be seen from the group, Figs. 152, 153, which represent but a

small proportion of those which are usually supplied. The best way to obtain these, whch scarcely average a shilling each, and the handles of which can be bought from a halfpenny upwards, according to material and finish, is to go to a regular tool shop, and select from the drawers and trays of such tools which will be presented to the view. Unless the wood is very hard indeed the gouge will come into use to commence work; but it must not take too deep a cut, or the edge will most likely be chipped and broken. In case of the hardest wood and ivory, a point tool, or one with a rounded edge, not too broad will be found most efficient. Both must be held horizontally upon the rest, and the best plan is to use them with a slight circular movement, Fig. 154, as if

FIG. 154



it was desired to scollop out the work. These tools should be brought to bear upon the material at the height of its axis, and the rest should stand as close to the work as possible, and be advanced as its diameter becomes reduced. When the work is sufficiently reduced to run evenly in the lathe a flat tool or one slightly rounded will level it; and if any beading is required or other mouldings, these can be readily produced by one or more of the tools already delineated. Hard wood cannot easily be mounted upon the taper screw or the prong chuck. If it is merely to be turned upon its cylindrical surface, the cross chuck can be used, two saw cuts being made for the purpose at one end. If it is to be hollowed out, a cup chuck of metal or wood must be used; or if the piece of hard wood is too short or too valuable to allow of the waste thus necessarily incurred, it should be glued upon the face of a piece of commoner wood which can be screwed to the taper screw chuck, or mounted in any other convenient manner. The tools used for hollowing out material of this description are called side tools, and are represented among the set shown

Some are rounded, some pointed, and some square, so that little difficulty need be found in making a selection for any special purpose. Turning in hard wood is easier than when the softer woods are used, but necessarily requires more time. Moreover, it is usual to expend a great deal of care in ornamenting such works with the various chucks and apparatus designed for that purpose. Ivory and bone may be worked with the same tools as are used for the hard woods. These materials, especially the latter, are disagreeable to work, owing to the peculiar smell caused by cutting them; but nothing can exceed the beauty of ivory when it has been carefully turned and polished. The specimens given in the large plate engravings in this work are to show what may be done in this material by skill and practice coupled with the use of proper tools and lathe fittings. They show, so far as it can be done by an engraving, the peculiar beauties of such ornamentation, but at best give only a faint idea of the appearance of the works themselves. It is not the object of the present treatise to enter into details of these operations, which would require more space than can be afforded; and "The Lathe and its Uses," combined with Engleheart's "Eccentric Turning," will supply most of the information upon this art which can be given by books. Practice only, coupled with artistic taste and facility in designing ornamental works, can make a proficient. Our present purpose is rather to give information in the simpler operations of the lathe, such as are required by those to whom this little work is specially addressed. Ivory may be purchased in the tusk, or in short pieces prepared for the lathe. It is always more or less costly; the price varying from about 6s. to 8s. per pound, according to quality. Some of it is fossil ivory, which is harder and not so pleasant as the newer tusk. Bones require to be boiled in lime water, to free them from grease. The better plan is to obtain some from the dealer's, picking out the best specimens. After being turned, they can be finished with sand-paper and polished with whitening and water. By procuring hollow pieces of the ivory tusk a great saving in price is effected, and pieces of various sizes can be obtained at very reasonable rates

sufficiently thick for many works. If solid pieces are taken and have to be hollowed out, it would incur great waste to cut away the internal portions as dust or shavings; and therefore it is usual to use a side parting tool, which is in the form of a rectangular hook, with an edge at the end, and which will be recognised in Fig 154*. It will cut out a solid core useful for other work. A

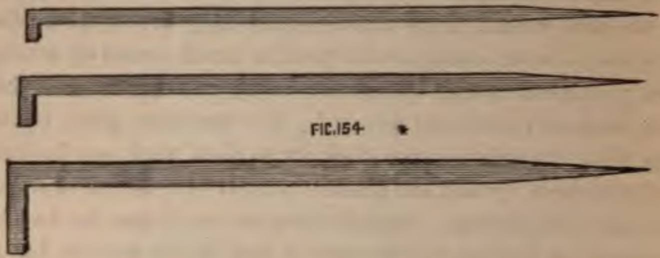


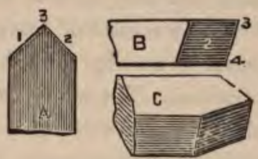
FIG.154 *

common parting tool is first used, applied at the end of the piece, to cut a circular groove, which will allow one of the side parting tools with a narrow edge and short hook to enter and commence to undercut the central block of ivory; the next sized hook follows, and so on until the piece falls out. Sometimes a hole is first bored in the centre of the piece, and the hook or side tool entered there, which is rather more easy to manage, but cuts out a ring of the material instead of a solid block Some care is requisite in thus using a thin parting tool which is wide in proportion to its thickness. The groove cut by it must not be too narrow, or it will cause the tool to jamb and break. The end of such tool is always made thicker than the rest of the blade, to prevent this jambing; but in a deep cut, like that just described, it is better to move the tool a little from side to side, still keeping its blade perpendicular, so as to add a little to the width of groove which it would cut if held quite still. The smaller in diameter the piece to be turned is, the more necessity there is for attending to this direction. Before proceeding to speak of metal-turning, the following hints may be worth remembering as applicable to turning in general:—Let the lathe itself be immovably fixed, and stand on a good floor; a stone pavement or a downstairs shop

is better than one upstairs. Have a good large window, and, if convenient, add a skylight over the lathe. Keep the rest as near as possible to the work. Learn to work the treadle without swaying the body to and fro, and keep the tool firmly upon the rest, not allowing the inequalities of the material to cause it to jump about. Do not cut too deeply, and keep the tools very keen.

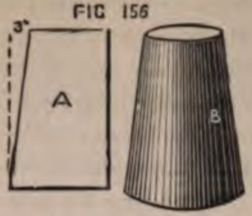
The turning of metal, though more tedious, is not more difficult than the preceding if the tools are rightly made and properly held. Attention has been called to this necessity by several men of scientific and mechanical attainments; and Mr. Dodsworth Haydon, an amateur, has summed up in a more compact form the several principles thus laid down. It is so important to attend to these principles that we shall risk being tedious, and give a sketch of the method to be pursued in grinding and sharpening such tools. With respect to the pillage of Mr. Haydon's work, there is reason in the mind of the writer why he should do so without fear of results, as Mr. Haydon wishes to make the mechanical world do these grindings and sharpenings rightly, *if he can.* To illustrate the matter, let a point tool be taken, Fig. 155. A, B, and C give

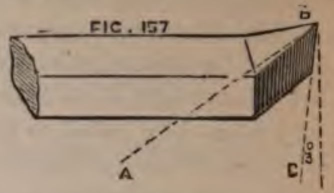
FIG 155



three views of the same. The first is taken from above, and represents the top or flat face of the tool; B is a side view; C, the same tool in perspective. In the first, we have at the extremity a point, 3, and two edges, 1 and 2. In the second, we have one side (2) visible, the point (3), and the *point edge* (3, 4). In the perspective view we have, in addition, the *bevel of the side* which faces us. Now, the first process in order to obtain a good tool is to take care that the angle of the face 1, 3, 2, Fig. A, is sufficiently large. It should not be less than 80° or 90°, because it is actually impossible, if this angle is as small as 60°, to produce at 1, 2, fit edges for cutting iron. Suppose the angle of 90° is taken

as the standard, this must be produced by grinding the sides, 2, in Figs. B and C, not perpendicularly to the upper or lower faces of the tool, but at an angle of 3° from the perpendicular. To effect this, a gauge, Fig. 156, is necessary, of which either side is 3°



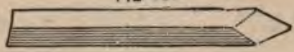


from the perpendicular. A is merely cut out of sheet tin or card. B is a cone of iron turned to a similar angle, and which is now, we believe, obtainable at Buck's, in Newgate-street, at which firm Mr. Haydon left a pattern of such cone turned by himself. This is a convenient gauge, as it can stand alone upon any flat slab, the lathe bed or slide rest plate, or even upon a slate. It is not the *point* 3, 4, Fig. B, which is to be thus gauged, but the *side bevel* itself, Fig. 155, C. After the two side bevels are thus ground until the flat face, Fig. 155, A, is of the form shown with a point at 3, there will be, as a matter of course, a bevel at the point 3, 4, Fig. B, which bevel is an edge formed by the grinding of the two side bevels as directed. The top or flat face is now to be ground back until a side view of such tool is like Fig. 157, the angle A B C being 45°. If the angle 1, 3, 2, Fig. 155, A, was 90°, as directed, there will be two cutting edges formed of an angle of 60°, fit for iron. When tools are intended to be rigidly fixed in a given position, as when a slide rest is used, the above *must* be carried out to make good work; and

in the case of such a tool as the above, supposed to be held horizontally, one of the two cutting edges should traverse the work while lying almost flat upon it. Thus the tool,

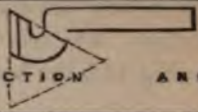
Fig. 158, moving in the direction of the arrow, should have the edge B B traversing the line A B. The first part of the double edge will thus cut the shaving in one direction, while the second, B, will detach it from the cylinder, leaving in its path a perfectly finished surface. The tool for general work by the hands only is the graver, Fig. 159, the face of which is lozenge-shaped. It is a

FIG 159



square or rather rectangular bar, ground off cornerwise at an angle of 45°, which gives cutting edges of 60°. This tool is held in different ways, but generally with the lozenge face downwards, or resting almost flat against the work which it has to cut. It will take off a good clean shaving in this way. Sometimes it is held with the lozenge upwards, but only for light cuts. Upon the whole, for outside work, no tool can beat it. Gravers are of all sizes; but in this and other tools strength is of less consequence if the forms and angles are right, and the cutting edge is held so as to make the smallest angle possible with the work. The clearage of 3° alluded to, is the angle which most tools should make with the work, and should not be exceeded. It will be noticed that the final edges are the result of grinding the top face of the tool at a given angle with the bevel of the point, 3, 4, Fig B, which bevel is itself the accident of the grinding the side bevels to meet at the point of the tool; but the final result depends also upon the angle 1, 3, 2, Fig. A. As this angle may vary within certain limits, and not all tools require cutting edges of 60° it is evidently necessary in practice to have some sort of Table which will give the final results of using certain angles at the point 1, 3, 2, Fig A combined with certain angles A B C, Fig. 157, the sides being supposed to be always ground by gauge to 3°. Such Table, compiled from numerous sources, and modified to make the work easier in practice, is given from Mr. Haydon's papers. To understand it we must give a name to the angles specified. The first 1, 3, 2, the original angle of the tool, is called its *plan* angle. The

final angle, Fig. 450, A B C, is called the *section* angle, and the angle of the cutting edges is simply called by that name.



PLAN ANGLE	WITH SECTION ANGLES		
140°	79.5°	69.°	58°
120°	78.5	67	55
100°	77.	63.5	49.5
90°	76.	61	45
70°	72.5	53.5	29
WILL GIVE — CUTTING EDGES	80°	70°	60°

It might be supposed that to cut iron great power would be necessary, and with badly made tools it is the case. Hence the old plan of long handles to pass under the workman's arm, with a cross handle nearer to the cutting part of the tool. Hence, also, sitting on the tool to keep it up to cut, which the writer has himself seen. But with tools of proper form the strain is slight, and the fingers, not the arms, come into use, although in heavy work the latter have to bear a fair share of the labour. In metal-turning generally the tools are held down upon a rest with a flat top—tolerably wide (half an inch to an inch). Whether they are to be held horizontally or otherwise depends, of course, upon their shape. The heel or hook tools cannot, of course, be so held; the the gra er may or may not be, the handle being generally held downward more or less. Brass-turning tools allow of various directions also, so that we can but refer the reader to the principle,

above stated, of letting the angle which the tool makes with the work be as small as possible (not over 3°), and taking care to grind the tool in other respects to suit the work. It is best to begin at

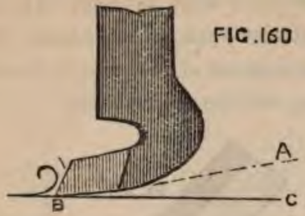


FIG. 160

the right-hand end of a cylinder, and as soon as possible to get the tool into cut below the outer-hand surface. This angle of 3°, it must be understood, is not a necessity of the cutting edges, but is

FIG. 161

FIG. 162

necessary to prevent the fixed tools from rubbing against the work. Thus, in Fig. 160, which is a planing or turning tool, the angle A B C, is this angle *of relief*, as it is called; and it is evident that it is not necessarily made by grinding the front of the tool, because the latter can be so fixed that instead of lying horizontally it can be caused to make such angle by its position. The graver, or any *hand* tool, can be held at the required angle so as not to rub against the work; but whenever the tool is to be fixed horizontally as it is in the slide rest, the angle of 3° must be preserved by grinding. The *principle* being understood, there is no practical difficulty in making any tool for any work, whether for inside or outside turning. It is easy to bend the iron right or left, up or down, to suit the work. The usual hand tools for iron are such as those represented in Fig. 157, but bent to suit special work, and often rounded at

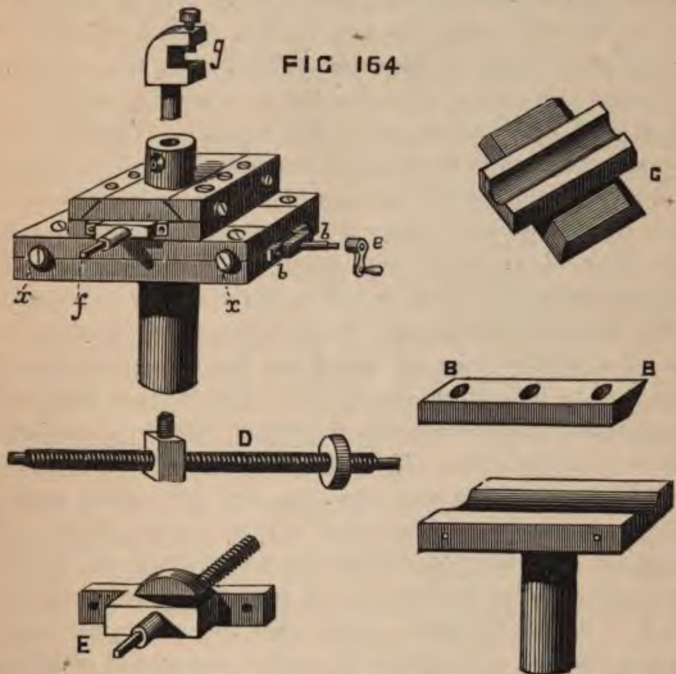
the point. For brass the edges must be at greater angles (80° to 90°), as lesser angles *dig in*. The graver, nevertheless, can be used for brass or gun metal, and will, with care, answer fairly. It is better, however, to use such tools as Figs. 161 and 162, which have rectangular, or almost rectangular edges. The heel tools, Fig. 163, give a great amount of leverage in favour of the turner. They are held as shown, and are of great use.


FIG 163

There is a great difference in the way in which iron, cast or wrought, is worked in the lathe by turners—generally speaking, this operation is very badly done, even with the help of the slide rest. The tools are clumsy, unscientifically made, and wrongly applied, and all imperfections are subsequently remedied by the file. If tools are rightly ground as directed, and water is used as a lubricant, not only should long shavings be cut off with little exertion, but the surface thus produced should be smooth and polished and require no subsequent application of the file. When, however, any *length* of exact surface is needed, it is almost impossible by hand alone to produce it, and a slide rest becomes necessary, Fig. 164. This addition to the lathe is made in various ways; but the principle is merely two slides working at right angles to each other, the upper one holding the tool. One slide being moved by a screw causes the tool to traverse the work lengthwise, the other causes it to advance or recede. Thus, if the tool is clamped in a proper position and is well made, the greatest accuracy is insured, and all that the turner has to do is to turn a small winch attached to the end of the traverse or leading screws.

It sometimes happens that the work is to be turned tapering, and then a third movement is required, and the main slide is made to work round a central pivot. On the whole, the writer approves of a very compact slide rest used on board ship for repairs of steam machinery, as the third movement is provided for by the whole machine being inserted in the socket of the ordinary rest. A sketch, therefore, is subjoined. The main figure represents the

FIG 164



whole in position. By the handle *e*, the lower slide is moved to and fro; by that marked *f*, the top slide advances or recedes, the tool holder (of which the best is Willis's) being attached to this upper slide. The latter, however, may have a socket like that of an ordinary rest to take the tool holder *g*, which allows of even greater variety of adjustment than Willis's. The other figures are added to show the details, in case the amateur should wish to try and make a slide rest. If he should so desire, no other pattern is

so simple as this, in which his only difficulty will be fitting the V-edges of the slides. They should be tested by a gauge of tin as the work proceeds; and with care and pains, fairly satisfactory work may be made. Iron castings are cheap, and the patterns will not be difficult to construct if the early chapters of our little book have been carefully read. The lower part is merely a rectangular plate of cast iron, which may be 9in. long by 7in. wide (more or less according to proposed uses), with a tang below to fit the rest socket; the tang must be turned, and the top of the plate planed, or otherwise rendered quite true and even. It is cast with a recess to receive the screw and nut, which latter is attached to the under part of the top slide. Two slips, B B, are screwed down to the surface of this plate, bevelled underneath: one is permanently fixed, and may be cast on the lower plate, but it is more convenient to shape correctly if made as a separate piece; the other slip is drilled with holes, which are afterwards filed so as to render them oval, and then this piece can be adjusted a little so as to be placed nearer to or further from the other; and to aid in this two holes are drilled and tapped in the side of the lower plate, into which screws (X X, Fig. 164) are fitted, with large heads, which bear against the slip or guide-strip, and keep it up to its proper place. *It is absolutely essential that these slips should be parallel to each other*, and the upper plate, made as shown, must slide smoothly and evenly between them. The slightest irregularity in this renders the rest useless. C is the next piece, also of cast-iron, and is recessed for the second screw and to lighten the parts, leaving only two rectangular narrow places requiring to be planed to receive another pair of bevelled slips, smaller than the last in every respect. The top plate is bevelled to fit between these bars, and contains on the upper surface either such a tool-holder as shown, or one of any pattern preferred to it. The only other addition requisite is the screw, which is seen at D, with the nut upon it, which nut is screwed into the under side of the top plate. This screw cannot advance or recede, owing to its flange near the head, which fits into a recess under the small plate E, in which it is shown in position. This

HALF DA,

revolves, the tool is slid along upon the rest at a rate proportioned to the speed of the piece and the pitch of the teeth, a spiral or screw will be cut. When it is considered, however, that the rate of motion of the tool must be uniform and always in a given ratio to the speed of the revolving cylinder, it will appear not only

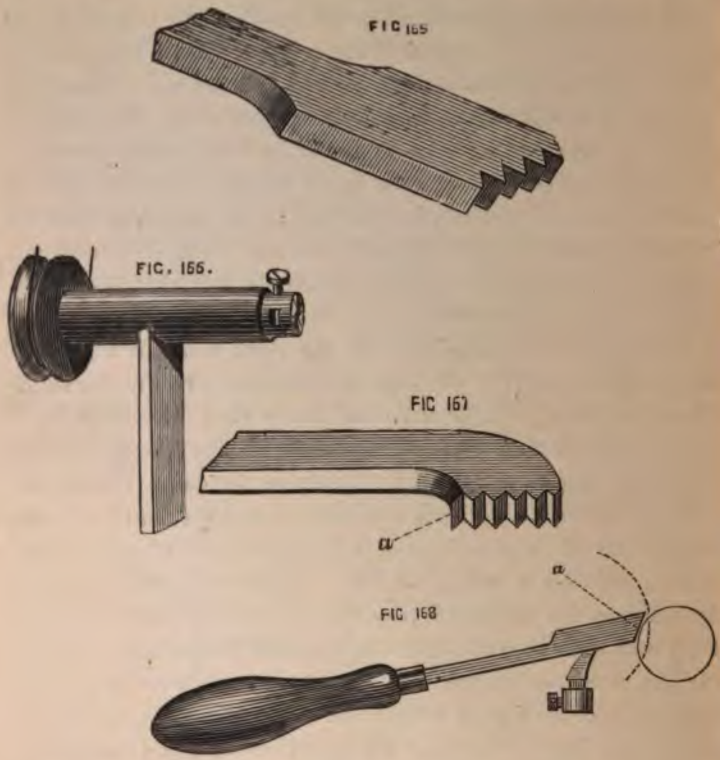


FIG 165
FIG. 166.
FIG 167
FIG 168

difficult, but next to *impossible* to fulfil the requisite conditions. Nevertheless it may be done, and, by practice, *is* done, every day, with very good results, and very fine-threaded screws can be thus made. A little attention to the following directions may assist, but practice is *the* essential, because all depends upon the acquired *knack*. If the tool is held as Fig. 168, with the front of the teeth

pressed against the work, these, being slanting, will tend, as soon as they indent the piece, to move along it, which, as soon as they seem to do, the cutting points must be lowered into action. Some say, begin by giving a twist to a single point tool, so as to cut a spiral, some part of which is sure to be of the required pitch, into which the teeth of the screw-chasing tool will catch, when it will begin to work. This seems a clumsy method, and in no way satisfactory, and it is better to take the right tool at once and make the attempt. If it is for a screw to a box, or similar work, leave the part too large, and then, if the tool goes right at first, you can cut down the threads a little, leaving enough of them to resume the action upon, and thus work safely; and, if the first cut is a failure, you can turn down to a smooth surface and try again. In this case there is a shoulder, and the tool has to be instantaneously removed when it touches it, or it will cross and cut to pieces the thread already made. The top of the rest, if indented, must be filed smooth and even, and it is a good plan to rub a little oil upon it to facilitate the traverse of the tool.

Metals may be thus screwed as well as wood; but of the latter it is necessary to use such as have a close, hard grain. Box will take excellent threads, but soft wood cannot be thus cut. and the only way is to use a V-tool of single point, which is vastly more difficult to manage.

The slide rest is beautifully adapted for cutting screws in metal, and there are various plans of effecting this. The simplest plan is to attach a pulley to the end of the leading screw, and carry a cord from thence to the overhead apparatus. If this pulley is proportioned rightly to that of the mandrel, a screw, or Elizabethan twist, can be readily turned in this way. Tools can be bought to fit into a holder for attachment to the holder of the slide rest, suitable for wood-turning. Short bits of steel tube, cut off sloping and sharpened, serve as gouges for soft wood; but short chisels and gouges, with the proper holder, are made and sold on purpose. Other apparatus is often added, such as small cutters, like miniature saws for cutting teeth of wheels. These are used in a holder like Fig. 166.

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